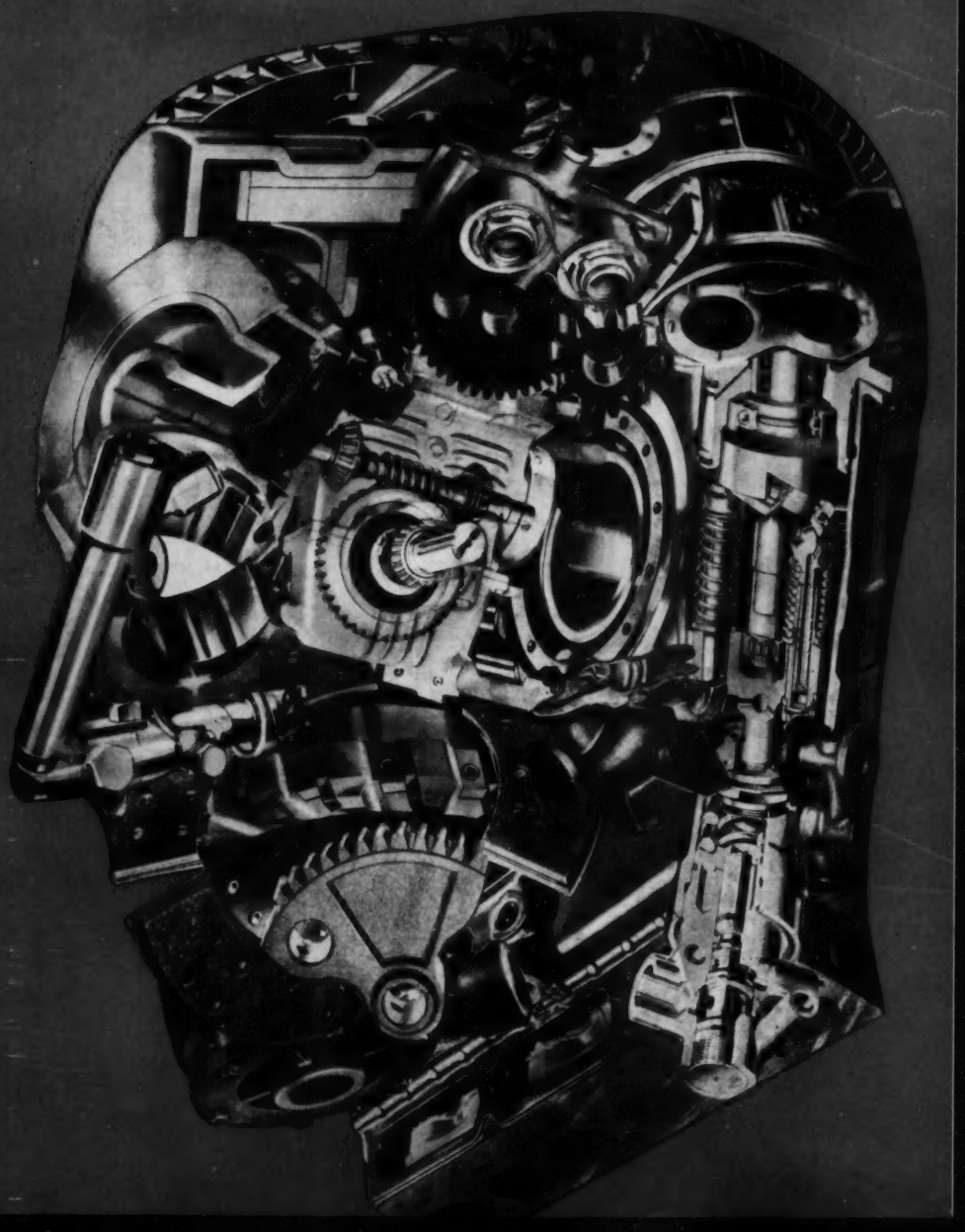
Engineering Materials and Design



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- ...draulic Stepless ...smission Systems

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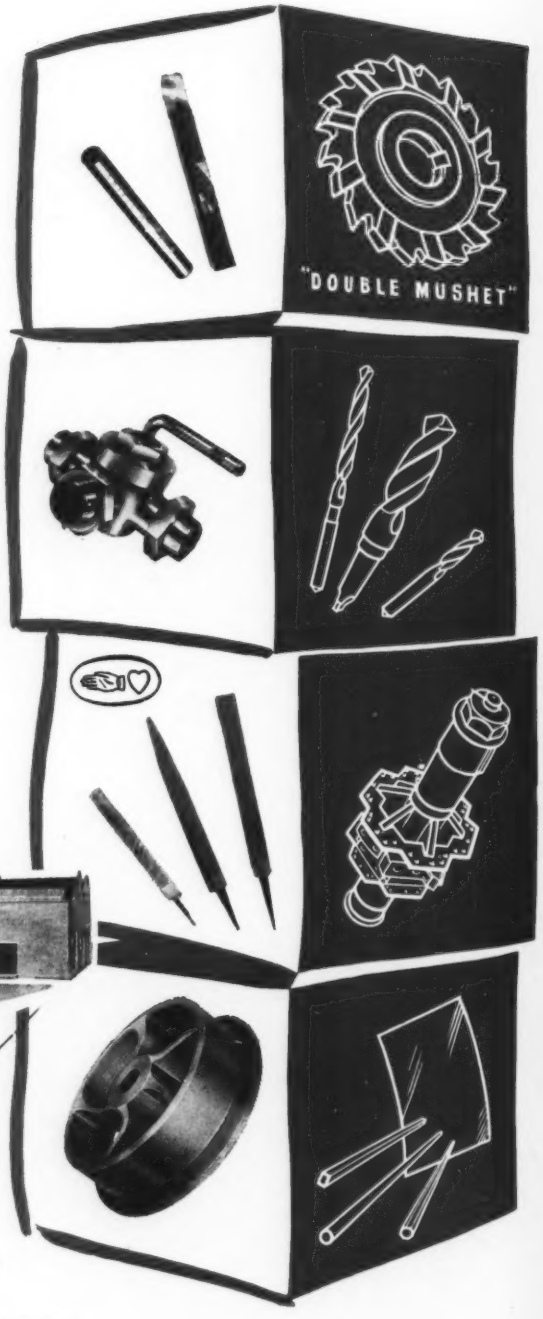

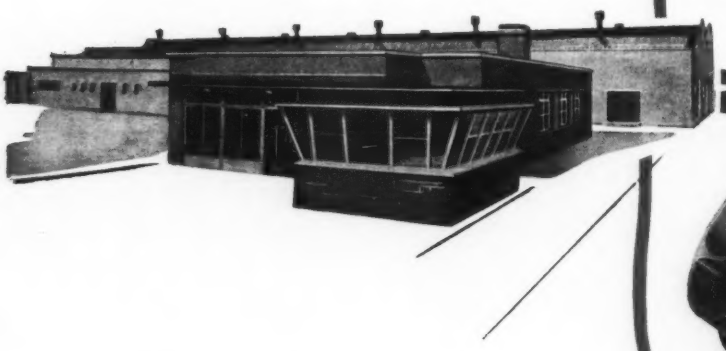

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

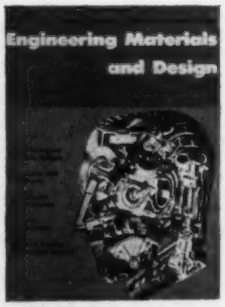
A HEYWOOD PUBLICATION

Vol. 3 No. 6 June 1960

EDITOR
H. R. Heap, B.Sc., A.M.I.E.E.

TECHNICAL EDITOR
R. D. Cullum, M.I.E.D., A.R.Ae.S., M.I.A.S.

ASSISTANT EDITORS
F. R. Terrell
P. Burton



COVER: What does the inside of a design engineer's head look like? We invited artist Lindlay Searle to give his impression for this month's front cover.

Published monthly by HEYWOOD & COMPANY LTD., Drury House, Russell Street, London, W.C.2 (Tel.: TEMple Bar 3422), on the 15th of the preceding month. Annual subscription 35s. sterling per annum ($5.25, U.S.A. and Canada) throughout the world. Single copies to order from all newsagents and bookstalls, 2s. 6d. each (by post from the publishers, 3s. 0d. each). BRANCH OFFICES: Royal Buildings, 2 Mosley Street, Manchester, 2, Tel.: Central 9935; Bayliss House, Hurst Street, Birmingham, Tel.: Midland 5786; 52 St. Enoch Square, Glasgow, Tel.: City 3492; 527 Madison Avenue, New York, 22, N.Y., Tel.: Plaza 9-1171.

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ISSUE AT A GLANCE

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Monel, nickel, ferritic and austenitic stainless clad steels.
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How stretching can enhance properties of the material.
By **J. W. Ladbury, B.Sc., Ph.D., D.I.C., A.R.I.C.**

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Review of types and purposes of filtration units.
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Résumés

ÉPURATION ET FILTRAGE DES LIQUIDES

K. E. Nicholds page 346

L'article décrit les diverses méthodes employées pour épurer l'air, les gaz et les liquides comme les huiles et les carburants de moteur ou les liquides hydrauliques. Il examine les résultats d'une absence de filtrage due à l'usure et à la décomposition du liquide. Il étudie divers types de filtres actuellement en production et leur comportement.

FABRICATION D'ACIERS CHEMISÉS

S. Rowden page 334

Un acier chemisé est une plaque de métal composée d'une base en acier commercial auquel est fixée une fine couche (ou chemisage) d'un métal ou alliage additionnel. L'article étudie la production, les propriétés spéciales et les applications des quatre principaux types d'acier chemisé : les aciers Monel, au nickel, ferritique et austénitique.

ISOLEMENT INORGANIQUE

S. Postle page 352

Le mica lié au verre peut être moulé par compression ou par injection dans presque n'importe quelle forme. L'auteur décrit sa manufacture et les propriétés qu'on peut en obtenir, ainsi que la gamme actuelle de ses applications industrielles.

FEUILLE ACRYLIQUE ÉTIRÉE

J. W. Ladbury page 340

On utilise maintenant intensivement, aux Etats-Unis, des feuilles acryliques étirées biaxialement pour la fabrication des hublots d'avions. L'auteur examine les avantages de l'étirage (renforcement des propriétés, d'où réduction du poids des hublots) et fournit de brèves notes sur sa fabrication.

ETUDE DES TRANSMISSIONS HYDRAULIQUES INFINIMENT VARIABLES

page 354

Cette étude fournit une sélection des principaux types de transmission hydraulique à rapports infiniment variables que peut utiliser l'ingénieur, depuis les systèmes de moins d'un cheval-vapeur jusqu'à ceux de plusieurs chevaux. Elle présente, pour les fabricants britanniques, des détails sur les tailles et spécifications.

Kurzreferate

REINIGUNG UND FILTRIERUNG VON FLÜSSIGKEITEN

K. E. Nicholds Seite 346

Der Artikel beschreibt die verschiedenen Verfahren zur Reinigung von Luft, Gasen und Flüssigkeiten, wie Treibstoffe oder hydraulische Flüssigkeiten. Die Folgen ungenügender Filtrierung, von Verschleiss und Zersetzung der Flüssigkeit werden beschrieben, sowie auch verschiedene Typen von Filtern, die gegenwärtig verfügbar sind.

ERZEUGUNG VON BELEGTEN STÄHLEN

S. Rowden Seite 334

Belegter Stahl ist eine zusammengesetzte Metallplatte aus handelsüblichem Stahl mit einem darauf aufgebrachten Belag eines Zusatzmetalls oder einer solchen Legierung. Der Artikel bespricht die Erzeugung, besonderen Eigenschaften und Anwendungen von vier Arten belegten Stählen, u. zw. Monel, Nickel-, Ferrit- und Austenit-rostfreiem Stahl.

ANORGANISCHE ISOLATIONEN

S. Postle Seite 352

Glasbondierter Glimmer kann im Spritz- oder Druckguss zu fast jeder Form verformt werden. Der Artikel beschreibt die Erzeugungsmethoden und die möglichen erreichbaren Eigenschaften, und gibt eine Übersicht der industriellen Anwendungsmöglichkeiten.

GEDEHNTE AKRYLPLATTEN

J. W. Ledbury Seite 340

Biaxial gedehnte Akrylplatten werden jetzt weitgehend für Fenster in U.S. Flugzeugen verwendet. Die Vorteile der Dehnung, die hierdurch verursachten verbesserten Eigenschaften, gestatten die Herstellung von leichteren Fenstern, und werden in diesem Artikel zusammen mit einer kurzen Uebersicht über die Erzeugung besprochen.

STUFENLOSE HYDRAULISCHE TRANSMISSIONEN

Seite 354

Ein Führer durch die Haupttypen von flüssigkeitsbetätigten, stufenlosen Transmissionen, die dem Konstrukteur zur Verfügung stehen u.zw. von Kleinsttransmissionen bis zu einigen PS. Der Artikel umfasst auch Grössenangaben und Kenndaten der Fabrikate gewisser britischer Fabrikanten.

Резюме

ОЧИСТКА ЖИДКОСТЕЙ И ФИЛЬТРАЦИЯ

К. Е. Николдс стр. 346

В статье описываются различные методы очистки воздуха, газов или таких жидкостей как машинного масла и горючего или гидравлических жидкостей. Обсуждаются последствия возникающие из за недостатка фильтрации, как от изнашивания так и от разложения жидкости. Рассматриваются различные типы существующих фильтров и их работные качества.

ПРОИЗВОДСТВО ПЛАКИРОВАННОЙ СТАЛИ

С. Роуден стр. 334

Плакированная сталь представляет собой составную металлическую плиту сделанную из подкладки торговой стали к которой прибавлено защитное покрытие или облицовка добавочного металла или сплава. В статье рассматривается производство, характерные свойства и применение четырех главных видов плакированной стали, а именно — монель-металла, никеля, ферритовой стали и аустенитной нержавеющей стали.

НЕОРГАНИЧЕСКАЯ ИЗОЛЯЦИЯ

С. Постль стр. 352

Слюда соединенная со стеклом может быть отлита в любую форму путем компрессии или инъекции. Статья описывает методы ее производства, качества которые можно при этом получить а также приводит все ее известные теперь применения в промышленности.

РАСТЯНУТЫЙ АКРИЛОВЫЙ ЛИСТ

Ж. В. Ладбэри стр. 340

Двуосно растянутый акриловый лист в настоящее время широко используется в США для окон самолетов. В статье обсуждаются преимущества растягивания, как то — улучшение характерных качеств, что ведет к уменьшению веса окон. Статья содержит также краткую заметку о производственном процессе.

ОБЗОР ГИДРАВЛИЧЕСКИХ БЕЗСТУПЕНЧАТЫ-ПЕРЕДАЧ

стр. 354

В статье приведен указатель для выбора главных типов гидравлически бесступенчатых передачных еденицъ в распоряжении конструктора, разных размеров, начиная от менее одной лошадиной силы и до нескольких лошадиных сил. Приводятся подробности размеров и других данных этих еденицъ для различных английских фабрикантов.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Automatic Supermarket

ONE OF THE MOST INTERESTING of the applications of the Gumpertz system of "automatic warehousing," for which Solartron-John Brown Automation Ltd. have world rights outside the U.S.A., is the automatic supermarket, which employs electronic techniques. The system enables, through electro-mechanical equipment, orders for articles to be assembled from a warehouse containing thousands of different commodities in a matter of seconds.

The shopper enters the sales area and picks up a blank card similar to a factory time card. She examines samples of the goods available and, on deciding to buy, she places her card in a slot where the name and size, or weight, of the goods are printed. She moves from display to display having her card printed as required. If she decides to change her mind, she crosses out the article printed on the card. Finally she returns to the cash desk and posts her card in a slot. It is read electronically and the price is indicated within a second or two in figures prominently displayed to her and the cashier. She pays her money and moves to a nearby booth.

While she is doing so, the cashier has moved a button release which causes the magnetic drum memory of the reader to signal the shopping list to the electro-mechanical system of the automatic warehouse. The goods are assembled and only 15 sec. after the pressing of the button, almost as soon as the shopper has arrived at her booth, her goods arrive for her shopping basket.

We are not sure if this is mechanisation, automation or computation, but there are obviously technical problems involved in designing and manufacturing such a system. Domestic shopping has always been a slow and inefficient process and it is encouraging to feel that it has now received due attention from those who design and make automatic labour-saving devices.

Silicon Developments

ONE OF NATURE'S most abundant elements, silicon, is fast becoming available to man in a highly purified form. Recently the general chemicals division of I.C.I. completed extensions to its silicon plant on Merseyside which raises capacity to 4,000 lb. a year. This plant, the first in Britain to make on a commercial scale the grades of silicon required in the manufacture of semiconductor devices, such as transistors and diodes, was brought into operation in 1959 but further extensions have been planned which will more than double capacity during 1960. This will be relatively simple, the original plant having been designed for ready expansion. Now as the result of an agreement with the Siemens companies of western Germany, Monsanto Chemicals Ltd. are to operate a silicon plant at its Ruabon factory in north Wales. Production will begin in the last quarter of 1960.

The Monsanto plant will produce float-zoned single crystals of high P-type resistivity or dope float-zoned single crystals of P or N-type resistivity. They will also supply polycrystalline rod for further processing, doping and crystal forming by customers. Float zoning, floating zone or molten zone refining is a process of refining in which a molten zone produced by H.F. induction heating is made to traverse a solid rod or bar of impure material, progressively purifying the material.

Silicon appears to have an interesting future and may prove to be of great importance in a variety of industries. Its superior properties at high temperature are making it an increasingly attractive alternative to germanium for applications such as solar batteries and rectifiers. A new market for these rectifiers is in motor car electrical systems where they are being tried out in conjunction with an alternator to replace the conventional d.c. dynamo. Weight savings of nearly 50 per cent are claimed to have been made by this change.

Utilising newly developed silicon-controlled rectifiers, the Garrett Corp. in the U.S.A. have built a gas turbine powered generator which produces 3,200 c/s electricity. This high frequency output is then statically converted to either 60 or 400 c/s. For the first time the new development frees the small gas turbine from restrictions imposed by the necessity of gearing high turbine r.p.m. down to low reciprocating engine speeds for which existing generators were designed.

A 100 kW turbine driven generator set is now under development and driving a high speed, shaft-powered generator directly mounted on the turbine, is expected to weigh only approximately 800 lb. as a complete set.

One of the big advantages is apparent in comparing this figure with the 5,800 lb. weight of the latest, lightweight diesel driven generator of equal output.

Resin helps Metal Build Bridges

TWO YEARS AGO a report from Germany announced the successful use of epoxy resins for joining members on a bridge, the resin replacing rivets. Now there is news from the Shell Chemical Co. of the use of epoxy resin, this time as a casting, on the Red Jacket Pill Bridge, which is part of the Neath By-Pass in south Wales.

The intention of the original design was that the lower ends of the vee-support units should be fitted when cast with convex mild steel bearing plates which, on erection, would fit into concave steel plates cast in the concrete of the pile capping beams. It was found, however, that it was impracticable to obtain the necessary degree of accuracy when setting the bearing plates during the manufacture of the precast concrete support units and concreting of the pile capping beams, to ensure an acceptable fit of the bearing plates on erection. It was therefore decided to create an artificial gap beyween the plates and to fill it with some suitable material. The gap was formed by placing hard rubber strips of ¾-in. initial thickness between the bearing plates, and the material used for filling the gap was an epoxy resin composition.

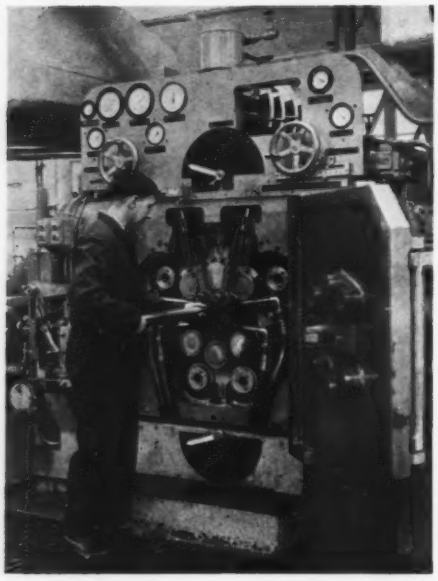
This material was chosen because of its high compressive strength and low shrinkage properties, bearing in mind that the weight of the superstructure to be carried on the bearings was 3,800 tons. The composition develops a high bond with steel and concrete, and in order to provide for the slight rotation of the support members under load, it was necessary to isolate the upper bearing plates from the resin. These plates were therefore sheathed with lead sheet.

High-temperature Thermocouple

RECENT INVESTIGATIONS reported by Johnson Matthey in the *Platinum Metals Review*, suggest that the noble metal thermocouple known as Pallador is satisfactory for use at 1000 deg. C. for long periods in air. The great virtue of this thermocouple is its high e.m.f., which is akin to that of an iron-constantan couple, but with greatly enhanced resistance to corrosion and a higher maximum operating temperature. At 1000 deg. C. Pallador gives over 60 millivolts which is about six times the e.m.f. of a 13 per cent rhodium-platinum couple; this makes the new couple of particular interest where low and medium temperatures are also to be measured. Pallador is a 40 per cent palladium-gold and 10 per cent iridium-platinum couple.

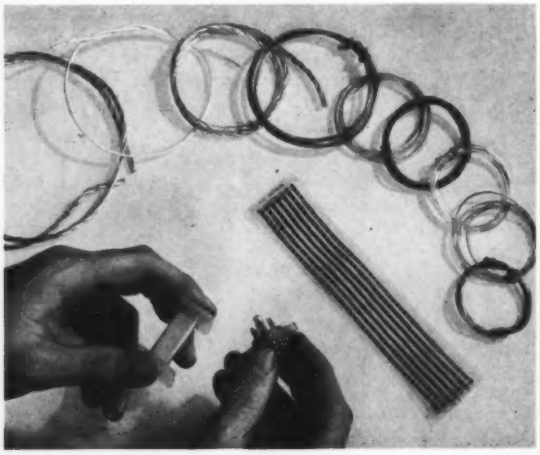
PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



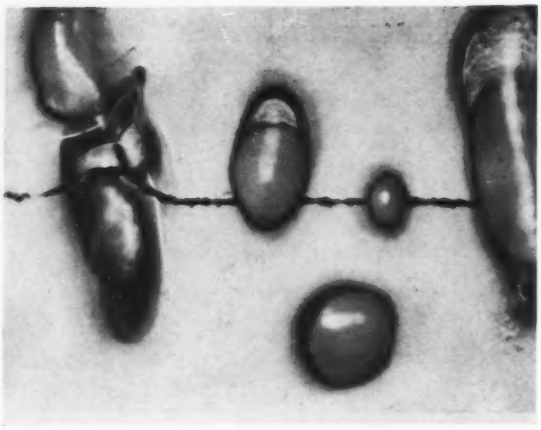
£1,000,000 MILL

A close-up of the Sendzimir mill recently installed by Birmetals Ltd. for rolling of aluminium alloys. The work rolls which the operator is seen inserting can be changed in less than one minute, so that the last pass can be made with highly finished rolls to produce a mirror surface on the strip.



VERSATILE PLASTIC

P.T.F.E. is shown here used for wire-coatings, flexible printed circuits and mouldings. The material used is Teflon 100x Perfluorocarbon resin made by the Du Pont Co.

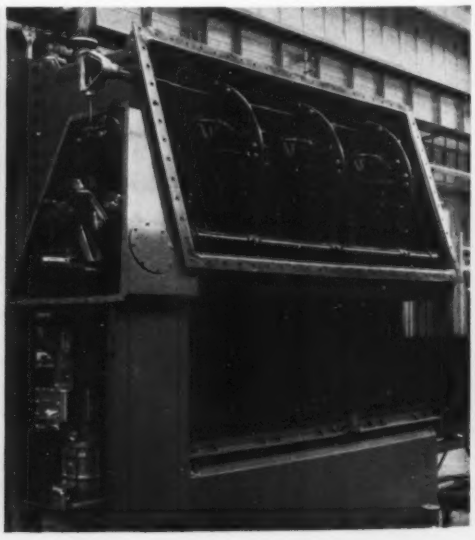


GASSING FROM METAL FAILURE

Gas bubbles, produced by repeated stressing on the surface of an aluminium specimen, leave their imprint in the adhesive material of a piece of transparent tape. The horizontal line is powdered material extruded from a fatigue crack, and some of the bubbles are associated with the crack (x700). (National Bureau of Standards.)

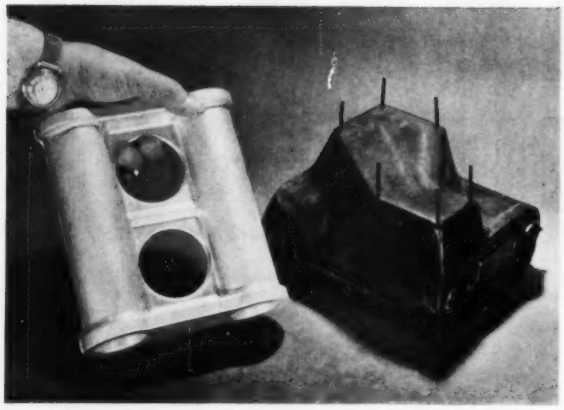
TAP-CHANGER INSULATION

Epoxy resin is used for this change-over switch moulding (left) which is part of the new English Electric High Speed Resistor on-load tap-changer. This unit has been developed for system voltages up to 500 kV.



POWER SCOOTER

Shown here with its inventor, Louis Richards of Illinois Technical College, the "Skeeter" can whisk a tired pedestrian along at 12 m.p.h. With aluminium foot platform and steering handle and a 1.32 h.p. model aircraft engine, the unit weighs only 12 lb.



TANK SHOES

The use of aluminium for track shoes on military tanks has resulted in a weight reduction of more than one thousand pounds on a medium tank. This forging produced by Kaiser Aluminium & Chemical Corp. is shown next to one with rubber treads applied.

TRANSISTORISED MIXER

The fact that transistors can now be used for satisfactory and reliable operation in all climates is an important factor in the design of this Marconi sound Console. Small size and weight leads to economy of operation which is further enhanced by the low power consumption.

MELT PROOF 'ICE'

Realistic imitation ice formations simulating the effect of severe icing conditions on air foil leading edges have enabled Boeing Airplane Co. to test the 707 jet liner over a full range of operating conditions. The 'ice' is made from glass fibre covered Styrofoam in the form of slippers which fit over the leading edges of the aircraft like heavy rime ice.

TRACTOR WITH 'FRIDGE AND RADIO

This ⅜ scale model tractor devised by Ford engineers may appeal to the gentleman farmer. It incorporates air conditioning, two-way telephone, food warmer, coffee maker, refrigerator and radio. The driver can watch on a television screen the action of rear mounted implements and there is even a sink!

E.M.D. 2897 for further information

GOOD CHROMIUM PLATING STARTS ON THE DRAWING BOARD

BECAUSE THE SHAPE of the work affects the way in which Nickel and Chromium are electrodeposited, attention to details of design can often make it easier for the plater to give you the high quality you need.

For example, the drawing should always indicate the surfaces (or parts of surfaces) where the high lustre is essential. The quality of the plating should also be stated i.e. quote the grading of the British Standard 1224; 1959. In this way you will be enabled to mark the finished products with "Quality Labels".

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Translucent Ceramic

FOR THE FIRST TIME IN HISTORY, according to the U.S. General Electric Co., a polycrystalline ceramic that readily transmits light has been made from powders. In addition to transmitting light, the new material is said to possess the extremely high strength characteristic of alumina ceramics, to withstand much higher temperatures than most ceramics now in use, and can be pressed into any shape desired. No other material combines translucence with this degree of strength, heat resistance, and ease of fabrication.

Lucalox, as the new material is called, is made from powdered aluminium oxide. It is closely related to sapphire and ruby gem stones, which are single-crystal aluminium oxide. The new polycrystalline form of the same compound is claimed to be superior to these gems in its ability to withstand high temperatures without deforming. Thus it may be considered to have the composition of a ceramic, the structure of a metal, and a light-transmitting ability approaching that of glass.

These unique characteristics result from the fact that the microscopically small pores or "bubbles" that are normally found in ceramic materials have been entirely removed, a feat that had been previously considered impossible.

Ductile Ceramics

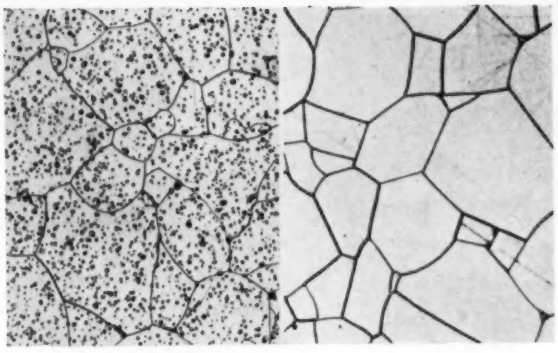
CERAMICS are sometimes considered for use in high temperature structural applications, but their greatest disadvantage is their extreme brittleness which in the past was believed to be an inherent property of these ionic substances. It has recently been shown that crystals of other ionic substances such as sodium chloride can be made to exhibit considerable ductility in bending tests at room temperature and it was reasoned that polycrystalline ceramics might also be made to exhibit ductility if the specimen surfaces were treated properly. In order to confer a degree of ductility to sodium chloride the surfaces of each crystal were coated with a very thin layer of silver or stearic acid and then compacted. Deposits of the type which have been successful in producing ductility in polycrystalline sodium chloride were also tried out on magnesium oxide before pressing, but the deposits were destroyed by the sintering process required to produce a ceramic body. However, now that the principle has been established there is hope that by finding a suitable material which will withstand the sintering temperature, ceramics with at least a small degree of ductility will be a possibility. This work is being carried out by the Lewis Research Centre in the U.S.A.

Liquid Gas Problems

LIQUIFIED PETROLEUM GASES (butane and propane) offer many advantages over other types of fuel, and as a consequence they are finding an ever-increasing number of applications in a wide variety of industries. An indication of the increasing demand for this fuel can be seen in the fact that the gas cleaning division of W. C. Holmes & Co. Ltd. have during the past year received orders for more than twenty-five L.P. gas plants ranging in size from 5-500 ton capacities.

The gases are stored in welded steel vessels at atmospheric temperatures and exert pressures varying from approximately 50-170 p.s.i. (propane) to 5-70 p.s.i. (butane). Since their boiling points are approximately —40 to —5 deg. C. respectively, the liquid can be readily converted to vapour.

The growing applications of liquified gases, such as methane, oxygen and nitrogen, which have to be handled and stored at extremely low temperatures have emphasised the great responsibility of the designer in selecting the correct materials of construction, because accidental release of these liquids may cause explosion and fire. Although many materials show an increase in strength as the temperature is reduced, some of them, including many common steels, lose their toughness and ductility. This is important because in order to withstand vibrations and shocks the materials must retain some ductility. Failure to observe this is believed to have led to a disastrous fire in the U.S.A. where a liquid methane storage tank of 3½ per cent nickel steel cracked after installation and let out the contents. Among the materials which do not lose their ductility at very low temperatures are copper, lead, nickel and austenitic and stainless steels as well as aluminium and some of its alloys.



The small pores found in normal ceramic materials (left) have been eliminated in Lucalox (right), a new translucent ceramic produced in the U.S. by General Electric.

Resin-bonded Quartz Sheet

A NEW MATERIAL with exceptional high heat-resistant properties has been developed by Cordo Moulding Products Inc. Called resin-bonded quartz sheet, it is a combination of reinforced plastics and ceramics. Both of these materials have been used with varying success in the rocket and missiles field, but neither alone is the complete answer to the extremes of temperature encountered in these applications. Resin-bonded quartz sheet, on the other hand, is claimed to have distinct advantages over either plastics or ceramics alone. It is also said to be markedly lower in price and to handle as well, if not better than such materials.

The name, resin-bonded quartz sheet, is highly descriptive of the nature of this new product. Finely-divided particles of fused quartz are bonded together with already proven high temperature-resistant Pyropreg resin. A small percentage of glass or other fibres is included to give the resultant sheet good handling properties. The sheet assumes the black colour of the Pyropreg resin and looks very much like a normal pre-impregnated fabric except that there is, of course, no cloth weave to be seen.

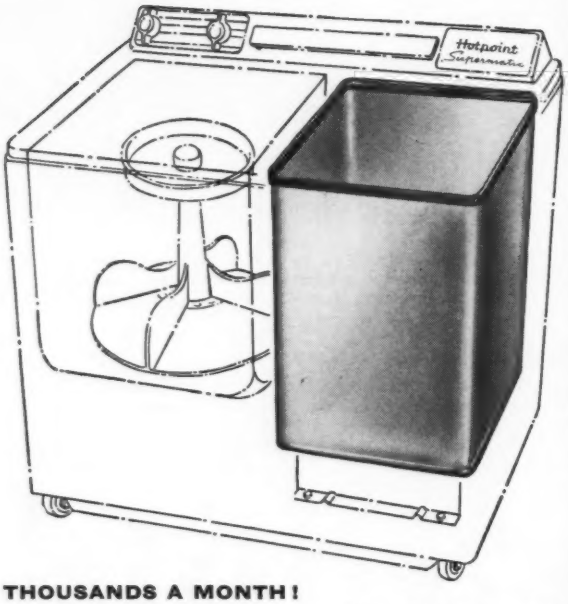
It is recommended as a facing on a laminate, for resin-bonded quartz sheet is not a structural material, and in the cured form has physical properties comparable to the resin itself. Its strength is ample for shielding properties but contributes little to the overall structure. The special property of exceptionally low ablation loss under extreme conditions is attributable in large part to the use of quartz. The fused quartz particles used in the sheet have an extremely low coefficient of thermal expansion. The melting point of this fused quartz is in excess of 1700 deg. C., and the resultant liquid is extremely viscous so that it is not washed off the surface but tends to act as an insulator for the material which is not yet melted.

Heat-resistant Adhesives

INVESTIGATIONS have recently been made by the Wright Air Development Centre to study inorganic polymer systems which might function as metal-to-metal structural adhesives at temperatures up to 540 deg. C. The investigations were purely exploratory in that an attempt was made to prepare inorganic polymers to meet the above requirements, the concept of an inorganic polymer being taken as a macro-molecule containing no carbon-carbon linkages.

The s-triazine and phosphonitrilic compounds were selected as the best approach because of their inherent thermal stability and reactivity, and six promising products resulted from the following reactions: (1) melamine-phosphorus pentachloride, (2) melamine-phosphorus oxychloride, (3) melamine-phosphorus pentoxide, (4) ammeline-phosphorus pentachloride, (5) cyanuric trihydrazide-phosphorus pentachloride, and (6) carbohydrazide-phosphorus pentachloride. These products are stable from 400 deg. C. to red heat, are generally insoluble, and they possess very reactive atoms which may be capable of modifications resulting in adhesive properties.

Attempts to incorporate metal atoms into an adhesive precursor were successful using titanium.



Feroglas for Hotpoint

THOUSANDS A MONTH!

J. W. Roberts are press moulding the Water Container for the Spin Dryer compartment of the new A.E.I.-Hotpoint Supermatic Washing Machine,* at the rate of thousands a month. Measuring $14\frac{1}{8}'' \times 11\frac{3}{4}'' \times 21\frac{1}{4}''$ deep and weighing $5\frac{3}{4}$ lbs., this is one of the largest and most difficult deep drawn glass-reinforced plastics mouldings made in this country.

WHY HOTPOINT CHOSE FEROGLAS

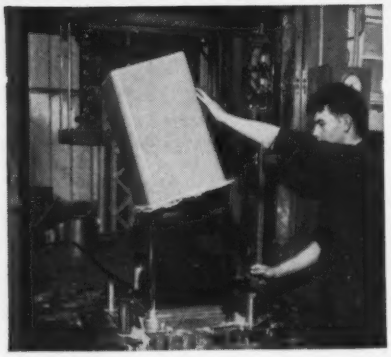
Feroglas scores over metal for the production of an article of such dimensions, making manufacture easier and more economical; the draw on the sides of the container is no more than 1° 21′. Strong but light, Feroglas is durable and withstands vibration. Non-corrosive, it is unaffected by constant contact with liquids.

J. W. ROBERTS STEP UP PRODUCTION

To meet Hotpoint's requirements, J. W. Roberts Ltd. are geared to manufacture at what may well be the highest production rate outside the U.S.A. for a single glass-reinforced press moulding. J. W. Roberts are taking it in their stride with big production facilities that include multi-drilling equipment. In a single operation lasting a few seconds this equipment drills 30 holes in the Hotpoint Container fully automatically. Soon the number of containers coming off this production line will be doubled.

This is only a stage in J. W. Roberts' expansion plan to meet the growing demands of Industry with modern, large production press moulding facilities.

● *The Supermatic is available only in Scotland at present.*



FEROGLAS

glass-reinforced plastics

J. W. ROBERTS LTD.
A Member of the Turner & Newall Organisation
Chorley New Road, Horwich, Bolton.
Tel: Horwich 840.
Branch Sales Offices: London, Glasgow, Birmingham, Leeds.

Other products include Sprayed **"LIMPET"** Asbestos—the all-purpose insulating material, and **"FEROBESTOS"** asbestos-reinforced plastics. (*Ferobestos bushes have, in fact, also been specified for the Hotpoint water container.*)

JWR39

Disc Brakes for Tractors

THE DISC BRAKE was introduced in 1945 to meet the braking demands resulting from the increased performance of jet power plants on aircraft. Although they are now normally associated with racing cars and high performance production cars, they are also being successfully employed in machine tools for the rubber, textile and printing industries, marine applications and for railway locomotives.

Dunlop Rubber Co. now announce the successful application of disc brakes to tractors. Complete enclosure of the brake within its housing is said to seal it against the ingress of dirt, and the tractor can be hosed down without impairing the brake's efficiency. They can be supplied with either mechanical or hydraulic operation. Advantages claimed for the use of disc brakes are automatic adjustment of friction pads and ease of maintenance, and these combined with the other features are said to provide an efficient solution to all the main problems of tractor braking.

Glass Fibre Spraying

THE DEVELOPMENT of large scale applications for glass fibre reinforced polyester resins has been greatly hampered by the messy hand mixing and hand lay-up methods formerly employed for small scale or experimental production runs. Aust & Schüttler u. Co. in Germany have developed a fibre-resin spraying process which overcomes many of the previous objections. Resin is contained in two pressurised tanks, one containing catalyst and the other containing accelerator and is applied by two spray guns arranged so that mixing of the two resin streams occurs just in front of the mould on to which the guns are directed. Glass fibre chopped to any desired length between ¼ and 5 in. (fibre length is quickly changed by a hand wheel which controls the speed of the cutting wheel) is fed along a wide bore flexible pipe and is ejected between the spray guns on to the work. Glass fibre can be applied at rates up to 140 lb./hr. and resin up to 240 lb./hr. so that large scale production can be planned for a single unit. After spraying the resin-glass surface is lightly rolled to exclude air and produce a smooth dense structure. Fillers can be incorporated in the resin if they are not abrasive or by a separate attachment if they are either very coarse (like vermiculite) or are abrasive. This equipment is available in the U.K. from Metropolitan Plastics Ltd.

Magnetic Field Annealing

ONE OF THE UNSOLVED MYSTERIES of metallurgy—magnetic annealing—is coming closer to solution through basic physical research being conducted at Bell Telephone Laboratories. For many years, it has been known that if soft magnetic alloys of nickel-iron (such as Permalloy) and nickel-cobalt-iron (such as Perminvar) are heat treated in a strong magnetic field, their magnetic moments will tend to align to produce a magnetically oriented material. This tendency arises from a uniaxial magnetic anisotropy introduced by the field heat treatment. The origin of this uniaxial anisotropy, however, has not been satisfactorily understood.

Bell Laboratories are also interested in the problem because large quantities of alloys such as Permalloy are used in inductor cores for communication equipment.

The theoretical basis for magnetic field annealing has been debated for some time. The generally accepted theory is based on short-range ordering of the metal atoms in the alloy. Recent work at Bell Laboratories however, indicates that magnetic polarisation does not result when these alloys are heat treated in a field unless about 14 p.p.m. of oxygen are present in the alloy. With less than this oxygen content, the annealed alloys do not respond, and no uniaxial anisotropy is developed.

At oxygen contents between 14 and 20 p.p.m., there is apparently little variation in the strength of the anisotropy. Although there appears to be little appreciable change in the magnetic response for reasonable increases above this level, substantially greater amounts of oxygen may result in the formation of oxides of the constituent metals.

While the mechanism by which oxygen causes this effect is not yet fully understood, it is believed that the oxygen atoms deposit on the stacking plane of the crystal at certain elevated temperatures, resulting in a displacement or dislocation of the next plane of atoms. When enough of these oxygen atoms are present, the alloy can be magnetically oriented by field heat treatment.

Confirming the theory is complicated by the fact that it is almost impossible to point out the location of the oxygen atoms in the alloys by x-ray or neutron diffraction techniques, or even whether the alloy itself has segregated, because of the similarity between the atoms of cobalt, nickel and iron. The minute quantities of oxygen involved also make the analytical problems difficult.

From a practical standpoint, it seems that more uniform magnetic materials can be produced by close control of the amount of oxygen present in the alloy. However, a great deal more study will be required before the theoretical basis for the phenomenon of magnetic annealing is understood in complete detail.

THE JULY ISSUE

of Engineering Materials and Design will include the following main features:

Rubbers for High-temperature Service
Selecting natural and synthetic rubbers for specific temperature ranges.

Designing Technical Documents
Clear meaning is more important than style in presenting technical information.

Niobium and Tantalum
Their properties and current applications.

Hydraulic Infinitely Variable Speed Transmissions
Second part of this survey of fluid-operated units.

Hydraulic Transmission in New York

THE NEWEST PRACTICAL DEVELOPMENT in transmissions, the first hydrostatic power transmission for vehicles, are being shown this month by the Dowty Group at the British Exhibition in New York.

The Dowmatic hydrostatic transmission has been accepted by design engineers as the first efficient application of hydrostatic power for vehicle use, and is now incorporated into British road-building vehicles, diesel locomotives, cranes and military vehicles, as well as being used in mining equipment, industrial drives, and marine applications.

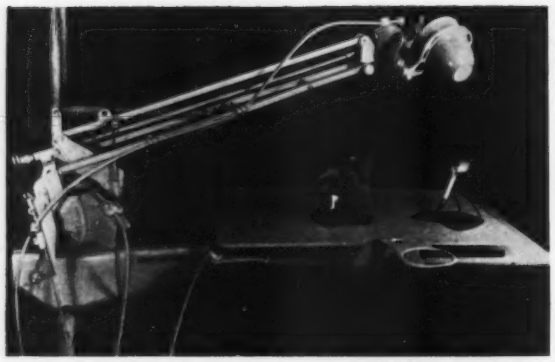
The advantages of a hydrostatic transmission using positive displacement pumps and motors in vehicles subject to frequent changes of gear and reversal of direction have long been recognised. According to Mr. Eric H. Bowers, director and chief engineer for Dowty Hydraulic Units Ltd., the Dowmatic offers "advantages unmatched by any other form of transmission to off-the-road vehicles engaged in heavy work requiring continual use of low gears and high manoeuvrability."

The British Exhibition will be the largest assembly of British industrial and consumer products ever shown in the U.S.A. Sponsored by the Federation of British Industries, it is also backed by the British Government, the Dollar Exports Council and the British-American Chamber of Commerce in New York.

Conference Proceedings

A REPRINTED version of the proceedings of the recent Engineering Materials and Design Conference at Earls Court is being prepared and will be available shortly. This will include all papers delivered, together with a full report of the subsequent discussion at each session.

Copies, price two guineas each, may be ordered now from Heywood & Co. Ltd., Drury House, Russell Street, London, W.C.2.



This is the Serviteur for use by the semi-paralysed, built from standard components, lifting the cup to the drinking position. On the table are a drawing pencil (right) and a spoon. (See "Design for Self-help".)

Design for Self-help

A PEDAL-OPERATED feeding mechanism for polio has been designed and built by two Coventry aircraft technicians, Mr. A. E. Harvey and Mr. J. Ainley. It is thought to be the only one of its kind in the U.K. The principle of its operation is similar to that of the remote handling tongs for the manipulation of contaminated objects at atomic energy plants, except that the cost of this mechanism is about £50 instead of £1,000. Mr. Harvey designed the Sonia Serviteur, as he has called the equipment, to help a semi-paralysed friend, unable to use her hands, to feed herself with only limited movements of the feet. Mr. Ainley, a fitter by trade, constructed the model.

To avoid the need for expensive servo-mechanisms and special machining operations, components from standard equipment were used for the prototype wherever possible. Thus the foot controls are connected to the eating utensils by Bowden cables. The "femur" is an Angle-Poise lamp bracket, the "hand" a car-type crocodile grip. A number of solderless nipples from motor-cycle controls were also used.

Although the object of the apparatus is to permit the patient to pick up easily a feeding utensil such as fork, spoon, beaker as well as an exercise pencil, it could be adapted to handle other accessories to suit the individual and perhaps occupational needs of the patient. For instance, a multi-push button switchboard or painting pellets could be controlled in this way.

It was found that the patient could not exert a force of more than 2 lb. even with her feet. The equipment, however, required from 2½ to 4 lb. force before it would operate and the inventors' solved it by spraying two coats of the Acheson resin-bonded dispersion of p.t.f.e., Emralon 820, on all inner cables and the sliding surfaces of the foot control. This reduced the force required to operate the mechanism.

Stopping Rush-hour Crush

TRAFFIC CONGESTION caused by large-scale commuting between cities and dormitory districts is a growing problem to engage the attention of engineers even more than of administrators in the next few years. Monorail systems have been talked of since the end of the last century—and one has in fact operated successfully in Germany for some years—but more recent developments in air bearings and air cushioning are likely again to revive hopes for its more intensive examination.

Two French companies are reported to be at present completing an experimental monorail line while at the Century 21 Exposition in Seattle next year, there is to be a monorail system to carry visitors between the business districts of the city and the exhibition site; designed by Lockheed Aircraft Corp., it will consist of tracks supported 20 ft. above street level descending to ground level at each end.

The monorail in the past has consisted of cars either suspended bat-like from an overhead rail, or else resting upon a single rail. Stability is obtained usually by guide wheels in a horizontal plane, though some experiments have been made in applying gyroscopic principles.

A British firm of consultants is at present working on what is said to be a unique system of passenger transport, the car of which will run at a maximum speed of 90 m.p.h.; a 5-mile test track is being constructed on the Continent for operation towards the end of this year.

London Transport is being currently urged to reconsider the use of a system seen at the Wembley Exhibition of 1925 and which was the result of a rather different line of thought. Developed by Mr. Yorath Lewis (of Lewis Adkins Ltd.), it consisted of a series of cars propelled by means of a helix-shaped rail running in a tunnel beneath the cars. By varying the pitch of the helix (which rotated at constant speed), the cars could be brought almost to a standstill at stations, the speed at these points being so low as to present no danger to passengers. Between stations the cars are moved faster by extending the pitch of the helix. The virtue of this method is not high speed but the carrying of a load in accordance with the demand made upon it; capacity can be made available whatever the passenger flow at a station, thus avoiding peak hour crushes.

Precipitation-hardenable Steels

PRECIPITATION-HARDENABLE stainless steels possess extremely high strengths after heat-treatment, their usable strength at elevated temperatures up to 800 deg. F. being comparable to any known material on a strength-to-weight basis. They are, however, among the hardest materials to fabricate. While being machined or formed into parts, they frequently develop residual stresses, and subsequent heat-treating, to bring out ultimate strength, releases these tensions and forms new thermal stresses, causing the parts to warp or spring out of shape.

An economical way of controlling these seemingly intractable metals has now been developed by the Boeing Airplane Co. Called cryoforming, the process utilises a known metallurgical transformation occurring in the metal during heat-treatment. Cryoforming produces warped or sprung parts to within 0.0013 for each inch of a 5-in. part. The machined, formed or welded part is heated to 1,725 deg. F. in a furnace as part of the hardening process. This may result in warping or other distortion. The part, cooled to slightly above 200 deg. F., is forced into a sizing die pre-warmed to 200 deg. F., and held by clamping, banding-and-wedging or simply by the pressure of the die itself. Part and die are then cooled gradually, the final cooling (to as low as −110 deg. F.) being done in a solution of dry ice and trichloroethylene, or in a dry cold box.

At some stage during the cooling cycle a metallurgical transformation takes place, and the crystalline structure of the metal changes; molecules of carbon and iron re-align themselves to form new and permanent alliances. During this transition the metal is believed to be momentarily pliable. The steel re-forms in the precise dimensions to which it is being held at the time.

When parts are removed from the cryoforming dies, the tendency to warp or spring back no longer exists. Parts show a close fit to design dimensions and usually can be furnace-aged without further restraint. Wrinkling and bowed-out areas are erased.

The new process is claimed to possess numerous advantages over other known methods. No additional facilities are necessary, nor is additional equipment, except for the cryo-forming dies, which may be made from steel, lead, aluminium and wood, depending on the amount of restraining force that is needed.

Parts can be cryoformed within the elastic limits of the material itself in simple or complex configurations and in conjunction with hydroforming, brake-forming, stretch-forming, hammer-forming and machining operations, with no limitation on size.

FOR MORE INFORMATION:—

Dunlop Rubber Co. Ltd., Holbrook Lane, Foleshill, Coventry.
Solartron-John Brown Automation Ltd., 20 Eastbourne Terrace, London, W.2.
Johnson, Matthey & Co. Ltd., 73 Hatton Garden, London, E.C.1.
General Electric Co., P.O. Box 1088, Schenectady, N.Y., U.S.A.
Shell Chemical Co., 170 Piccadilly, London, W.1.
I.C.I. Ltd., Imperial Chemical House, Millbank, London, S.W.1.
Garrett Corp. (AiResearch Mfg. Div.), 402 S. 36th Street, Phoenix, Ariz., U.S.A.
Metropolitan Plastics Ltd., Glenville Grove, London, S.E.8.
Monsanto Chemicals Ltd., 10-18 Victoria Street, London, S.W.1.
Lewis Adkins Ltd., 17 Woronzow Road, London, N.W.8.
Bell Telephone Laboratories, 463 West Street, New York 14.
Dowty Group Ltd., Arle Court, Cheltenham, Glos.
Boeing Airplane Co., Seattle, Wash., U.S.A.
W. C. Holmes & Co. Ltd., Turnbridge, Huddersfield.
Cordo Moulding Products Inc., 230 Park Ave., N.Y., U.S.A.

DESIGN FOR FAILURE

ILLUSTRATED reports on engineering failures make fascinating if somewhat depressing reading. Fascinating because they often bring to light unusual forms of failure which at first appear to defy the laws of mechanics and depressing because some of the failures are due to well-known factors which should have been allowed for in the original design. Both types of failure were described in a recent paper to the Institute of Marine Engineers by Mr. H. N. Pemberton, who is the chief engineer surveyor to Lloyd's Register of Shipping, and who suggested that "ideally, perhaps, there should be no failures in marine machinery". This ideal is probably already held by many designers, in other fields of engineering, although for practical reasons it is not often achieved.

However, in dealing with design problems which are less extreme, there is always the difficulty of deciding to what extent reliability and durability should be sacrificed for the sake of performance or cost. Fifty years ago it might have been felt that efficient design was the act of creating machinery and equipment so robust that it never broke—what we may call designing for safety. Progress and competition now demand that we design engineering equipment with more rational safety factors and this can only be carried out successfully if we know with a fair degree of accuracy the point of failure. In calling this design for failure, we mean that products should be designed so that where, when and why they fail are known; particularly if products can be designed to fail safe, this could well be the ideal for the modern designer.

If the engineer of fifty years ago had difficulty in achieving his ideal, and we know he was not always successful, then his counterpart today is faced with much greater problems. In designing for failure, such factors as fatigue, stress corrosion and fretting become of much greater significance than they would otherwise, and unfortunately they are not, even today, understood as thoroughly as the designer would wish. To compensate, at least partially, the increasing experience with computers of various kinds has given the designer a means of putting his ideas to test without the necessity for enduring an embarrassing service failure. At the same time it appears that the computer services now available in this country are not being used as much as they should be for this type of problem.

Service failures are not usually the subject of publicity for obvious reasons and, apart from some excellent publications by insurance companies who have a real commercial interest in finding out the causes of failure and preventing their reoccurrence, it is extremely difficult to obtain technical data on this from manufacturing concerns. Many companies operate a large service department whose main occupation is replacing or repairing broken machinery, but it is rare to find a company operating an efficient F.I.D. (failure investigation department) to advise designers on the causes of failure. Many firms seem to operate without any visible link whatever between the service and design departments.

In echoing Mr. Pemberton's sentiments that engineers should appreciate the significance of failures so that they can guard against them in the future, may we suggest that designers should not wait for their companies to make the first move, but they should seek to uncover the secrecy which frequently prevails and so transform a weakness into what should be a source of strength.

The Editor

FABRICATION OF CLAD STEELS

Clad steels are now finding wide application in many industries; this article describes the production and special properties of four main types — Monel, nickel, ferritic and austenitic stainless steels

by S. ROWDEN, A.I.M., A.M.I.W.*

THERE are many types of composite metals or special synthetic surfaced steels, but only one class can fit the real definition of a clad steel. A clad steel is a composite metal plate made of a commercial steel backing material to which is bonded a veneer or cladding of another metal or alloy, the latter being usually heat- or corrosion-resistant. Shear bond strengths are naturally also of importance; while the A.S.T.M. and A.S.M.E. specifications call for a minimum of 8.8 t.s.i., the majority of clad steels far exceed this figure.

Undoubtedly, the economics of using composite metal steels has been partly responsible for the large tonnages used in industry today. By judicious bonding of ferrous and non-ferrous materials to steel, a means has been found of utilising the inherent physical and mechanical properties of both materials, without the necessity of fabricating wholly in the more highly alloyed material. While clad steels are cheaper than solid alloyed materials, rather more care is required at all stages of fabrication than with plain mild steel or even some of the solid corrosion-resisting metals. Cladding thicknesses vary from 10-20 per cent of the total plate thickness and only in special circumstances would the latter figure be exceeded.

Main Production Methods

The forged pressing method of manufacture consists of placing the previously cleaned cladding material on to the prepared mild-steel slab. These may then be held in place by welds, and a second similarly-prepared plate is put on top of this with the clad surfaces facing, but kept apart by a layer of infusible refractory compound. Such a double sandwich is then hot rolled at 1,250 deg. C. to the desired thickness. Under duress of heat and pressure the clad plate is metallurgically bonded, and the sandwich pack yields two clad plates.

Welding methods of cladding consist of a simple overlay on mild steel by metallic-arc process; this leads to the desired depth, employing an electrode of composition similar to that required for the clad material. Later, hot rolling similar to the pack method would be used to achieve the same result. Resistance welding is sometimes used, as also is the intermelting technique for some non-ferrous alloys. Generally, however, the forged-pressing or arc-fusion processes are adopted.

* *Ashmore, Benson, Pease & Co. Ltd.*

Types of Clad Steel

It is proposed to deal with four main types of clad steels, namely Monel, nickel, ferritic and austenitic stainless steels. Numerous varieties of bonded dissimilar metals exist, including the less common Inconel, copper and aluminium materials. However, only the most common types of integrally bonded composite steels will be discussed here, and only as homogeneous bonded metals in plate form.

Table 1 outlines some of the more common classes of alloyed materials used for composite plates. For the backing steel a normal boiler quality material is invariably utilised: such steels include B.S. 14 and the respective grades of B.S. 1501. Where it is required, other specialised grades of steel may be used, although this is the exception rather than the rule.

FERRITIC STAINLESS STEEL—Perhaps the most common type of cladding used in the ferritic stainless steels is the A.I.S.I. Type 405. This is the 13 per cent chromium steel with aluminium additions; metallurgically, the latter element is reputed to restrict air-hardening tendencies. A.I.S.I. Type

TABLE 1. Common alloyed materials used for composite plates

Steel	B.S.I.	A.S.T.M.
13% Chromium + Al additions	1501–713	A.263 Type 405
Unstabilised 18/8 Cr/Ni	1501–801 Grades B & C	A.264 Modified 304
Stabilised 18/8 Cr/Ni Steels	1501–801 Grades Ti & Nb	A.264 Type 347 niobium bearing A.264 Type 321 titanium bearing
Stabilised 18/8 Cr/Ni Steels + molybdenum additions	1501–845 Grades B & Ti	A.264 Modified 316
Low-carbon nickel	1822	B.162
Nickel	1822	B.167
Monel	—	B.127

TABLE 2. Nominal compositions (%) for steels and alloys listed in Table I

Steel	C	Cr.	Ni	Ti	Nb	Mo	Other
B.S. 1501–713	0·08 max.	11·5–13·5	0·6 max.	—	—	—	Al 0·1–0·3 S & P 0.045 max. Mn 1·0 max.
A.S.T.M. A.263 Grade 0	0·08 max.	11·5–13·5	— 0·6 max.	—	—	—	Al 0·1–0·30 Mn 1·0 max.
B.S. 1501–801 B	0·08 max.	17·5	8–11	—	—	—	Mn 2·0 max.
„ C	0·08 max.	17·5–20	10 min.	—	—	—	Si 0·20 min.
B.S. 1501–821 Ti	0·12 max.	17–20	7·5 min.	4XC	—	—	Ti 0·7 max.
Nb	0·08 max.	17–20	9 min.	—	10XC	—	Nb 1·0 max.
B.S. 1501–845 B	0·08 max.	16·5–18·5	10·0 min.	—	—	2·25–3·0	Mn 2·0 max.
Ti	0·08 max.	16·5–18·5	10·0 min.	—	—	2·25–3·0	Mn 2·0 max.
B.S. 1501–846	0·08 max.	18–20	11–14	—	—	3·0–4·0	Si 0·20–1·0
Nickel (low C)	0·02 max.	—	99 min.	—	—	—	—
Nickel	0·15 max.	—	99	—	—	—	—
Monel	0·3 max.	—	Basically 70 % Ni—30% cu.		Fe 2·5 max.		

410 and even the 440 steels have been utilised, but are comparatively obscure and the following remarks are designed and applicable to the 405 material.

The general principles already outlined suggest the problems which are to be overcome. Even with the inhibited air-hardening characteristics 13 per cent chromium is susceptible to "cold cracking". As the term suggests, this is in direct contrast to the type of cracking frequently found in austenitic stainless steels, often referred to as "hot cracking" or micro-fissuring.

Since it is established that 13 per cent chromium air hardens from the temperature of welding, electrodes of a similar composition should be avoided. If this is unacceptable because of service conditions, then an adequate preheat temperature should be applied and maintained throughout the welding operations on the clad side. Furthermore, especially in the case of thin claddings, some compensation of dilution effects should be avoided, i.e., selecting an electrode with a chromium content 2-3 per cent higher than that of the cladding. If a 13 per cent chromium electrode is used, a suggested preheat temperature is 200 deg. C. minimum. Post heat-treatment is equally important and may be carried out at 700-750 deg. C. This treatment not only serves as the conventional stress-relieving process but tempers any hard and brittle zones.

If one has a choice of electrode for welding the cladding, then unquestionably an austenitic stainless steel is to be preferred. Mechanically, it will match the strength of the cladding, while its corrosion resistance will almost certainly prove superior. Using such an electrode will eliminate a brittle weld deposit and under specific compositional influence ease the actual welding process. Ferrite-controlled electrodes assist particularly in this respect, although one should not choose such a welding rod purely on this score since the resultant service conditions could, under some environment, offset this.

Electrodes of 25/20 chromium-nickel are most popular when an austenitic electrode has been decided upon, but this does not preclude the use of 25/12 chromium-nickel or even 18/8 chromium-nickel electrodes. On the assumption that a 13 per cent chromium electrode is excluded, and that stress corrosion failure of an austenitic weld deposit is a service possibility, then recourse to a nickel-base electrode can be considered. Some success has been obtained when an electrode of this type has been chosen to fabricate vessels to a Class 1 standard, the electrode being well-established Inco-Rod A.

AUSTENITIC STAINLESS STEELS—Straight 18/8 (stabilised or otherwise) and molybdenum-bearing chromium-nickel steels comprise the vast majority of stainless composite plates. Quite often, the molybdenum steel shows an increase in the nickel content to restore an austenitic structure, the original balance having been offset by the strong ferrite-forming tendencies of the molybdenum. It is not uncommon to find these steels designated 18/8/Ti for the titanium stabilised, 18/8/1 for the niobium stabilised and either 18/8/Mo/Ti or 18/10/Mo/Ti for the stabilised molybdenum materials.

By virtue of carbon pick-up from the mild steel and possible dilution effects, 25/20 electrodes are sometimes advocated when welding the cladding. This is particularly true of the relatively thin clad plates. However, it may be recommended as sound practice to make the root runs on the clad side in these highly alloyed, though expensive, electrodes, and complete the welding using 18/8 chromium-nickel electrodes.

Since dilution effects and carbon migration are of the utmost importance the clad side of a weld occasionally has to be made with a specified number of runs, with a minimum dependent upon the cladding thickness.

MONEL—In the welding of Monel-clad steels the fabricator must face up to the challenge of numerous perplexing problems. The common credentials of clad welds such as strength, ductility and an overall radiographic soundness must be met, together with attendant problems applicable to high nickel bearing materials. It was shown earlier that such alloys are prone to intercrystalline films of a nickel-sulphur eutectic and, under certain conditions, susceptible to oxide contamination. Procedures which are satisfactory for many engineering materials are not acceptable to nickel alloys and if such phenomena are to be avoided extra care must be exercised during all stages of fabrication. Unfortunately, the damage is not readily obvious and could only be detected by bend test samples or preferably microscope examination.

The first run on the clad side is extremely important—more so in fact that the pure nickel-clad plate. Not only must one safeguard against impairing corrosion resistance

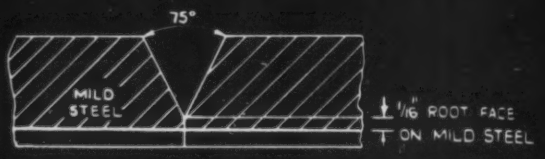


Fig 1

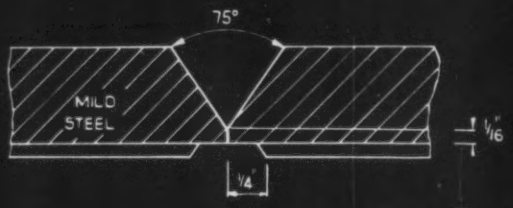


Fig.2

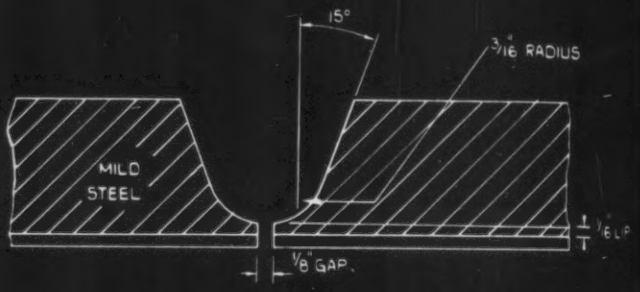


Fig.3

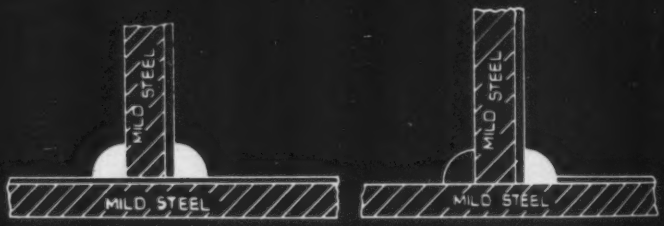


Fig.4

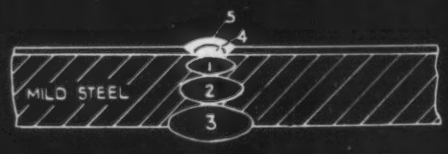


Fig.5

Fig.6

Fig.7

(which would be a function of carbon and iron pick-up), but Monel welds are prone to hot-cracking. Two procedures have been used in this respect to eliminate the problem. A specially developed Monel electrode, low in carbon content, avoids the inherent brittleness at the dissimilar metal interface, while use of a pure low carbon nickel weld deposit for the first run has been championed by many people. If the latter techniques were adopted then the weld could be completed using a standard type of Monel electrode.

Limits of iron dilution in Monel deposits depend to a large extent upon ultimate service conditions. In an attempt to minimise such a phenomenon it is better to use a shallow stringer bead technique. In addition, and provided no code requirements are being violated, an extra run at the first-pass stage on the clad side may prove helpful. This could be accepted in lieu of the mild steel run which would be applied following the back chipping to sound metal.

NICKEL—Most of the remarks concerning Monel-welded composite plates are equally applicable to nickel-clad steels. For the majority of applications, iron contents in the weld deposit are fixed between 3 and 5 per cent. The stringer bead technique used in Monel welding is also used for nickel. However, progressive grinding of the nickel weld runs, and subsequent restoration of deposit, assists admirably in keeping iron contamination to low levels.

Not unnaturally, composite nickel plates $\frac{1}{4}$ in. thick will present further difficulties insomuch as extra care is needed to avoid penetration through the cladding when welding the mild-steel side, and it is sometimes difficult to maintain the optimum number of runs on the clad side. By modifying the weld preparation, one could dispense with this difficulty by welding the plate throughout using nickel electrodes. Alternatively, there are reputed good results when the nickel cladding has been welded with an electrode of similar composition and the mild-steel backing welded with austenitic stainless steel or Inconel electrodes.

If the plate thickness is greater than $\frac{1}{16}$ in. then the clad layer could probably be welded in two runs, which would allow the first one to go substantially back into the mild steel, following the back chipping treatment. This point was made also in reference to the welding of Monel-clad steels.

Forming Operations

Forming operations can, thickness permitting, be carried out cold. However, some precautions are necessary if the bond is not to be impaired; notably maintaining radii of generous proportions and rounding off all edges which are inclined to be rather sharp. Dies and blocks, rolls and the plates themselves should be free from scale and other foreign materials throughout pressing operations, since the corrosion resistance may be lowered appreciably by the presence of such materials embedded in the cladding.

Where forming is to be achieved with the plate at elevated temperatures it is the cladding which governs the chosen temperature. Unfortunately, this may result in the mild-steel backing losing some degree of ductility and notch toughness. Retrieving these properties would depend entirely upon the degree of hot working time held at temperature and any subsequent heat treatment.

The affinity of nickel for sulphur and oxygen demands extra care when nickel-clad steels are hot worked. Furnace atmospheres should preferably be of a reducing nature and, ideally, sulphur free. In addition, sulphur embrittlement can be minimised by ensuring that the plates are absolutely clean prior to charging to the furnace; in particular, paints, oil and grease must be removed. Clad surfaces should invariably be uppermost in all punching and shearing operations. This will ensure that the trailing rag is on the mild-steel side of the plate, where it will be least harmful. Where plate edges are to be subsequently machined, e.g., weld preparations, then this effect may be ignored.

TABLE 3. Nominal compositions of common mild-steel backing material

	B.S. 14	B.S. 1501-151			A.S.T.M. A.285 Grade C Firebox
C %	—	—			0·25–0·30, according to plate thickness.
Mn %	—	—			0·80 max.
S %	0·05 max.	0·05 max.			0.04
Si %	—	—			—
P %	0.05 max.	0.05 max.			0·035 max. basic; 0·04 max. acid.
		A	B	C	
U.T.S. (t.s.i.)	26–30	24–28	26–30	38–32	24·5–29
% Elongation	23	25	23	20	25 (on 8 in.) 29 (on 2 in.)

Flame cutting should be initiated from the mild-steel side and where arc-air gouging has been utilised favourable results have been obtained when the cladding was cut first. With respect to gas cutting operations, it is frequently necessary to preheat the plate prior to the flame cutting action.

Welding

One basic fundamental approach in the welding of clad steels is to treat the respective materials as isolated plates, each to be welded in its own right. However, occasions do arise when the whole weld may be completed with an electrode matching the composition of the clad material.

The thought which must be uppermost in the mind of the fabricator when welding clad steels is one of successfully joining the sections, but still maintaining the homogeneous alloy layers. In other words, not only must the joint strength be satisfactory but also the welding on the clad side must as far as possible be able to withstand the corrosion which will attack the cladding itself.

Practically without exception, all clad steels are welded in the downhand position. Furthermore, the greater majority are welded by manual metallic-arc methods, automatic open-arc and submerged arc welding being comparatively rare in this country.

Choice of electrodes or filler material must be germane to the materials being welded; the actual selection will be dealt with under the individual classification.

Unquestionably, it is true to say that the greater the cladding thickness, the less will be the difficulties of diffusion of clad weld deposits. It is not possible to generalise upon the minimum thickness which can be welded, since variables such as ultimate service duty, the proficiency of the welder and, naturally, techniques employed all influence the thickness. From a fabricator's viewpoint it is felt that the minimum thickness of cladding should be $\frac{1}{8}$ in.

BUTT WELDS—Figs. 1 and 2 show weld preparations for $\frac{1}{16}$ to $\frac{1}{4}$ in. overall thickness of composite plate. Typical conditions for this design would be to weld the mild-steel side using a multi-pass technique and avoiding penetration through to the clad layer. The deposit should then be back chipped from the clad side, until sound slag-free metal is reached. Completion of the alloy layer may then be carried out; however, electrodes and techniques differ, since they are a function of the class of alloy material.

In Fig. 3 it will be noticed that the cladding has not been

stripped from either side of the mild-steel weld. In the case of bonded steels exhibiting 20 per cent cladding thickness, i.e., cladding of greater than ¼ in. thickness, the method of preparation shown in Fig. 2 (the cladding removed prior to welding) is to be recommended.

FILLETS—Whenever possible, clad steels should always be welded in the downhand or flat position. This is equally true of fillet welds, though, of necessity, some positional welding is inevitable. Irrespective of welding procedure, the fillet joints shown in Fig. 4 may be considered as fairly common in such cases.

Improvisation on these joints is acceptable as long as the essential requirements are always fufilled, particularly avoiding dilution effects detrimental to the finished weld, achieving adequate joint strength and eliminating thermal hardening of the clad material.

The latter remarks readily confirm why butt welds are considered the optimum joints.

Conclusions

It is obvious that some degree of flexibility exists in the respective techniques and conditions necessary in the welding of clad steels. Invariably when undertaking to fabricate clad vessels there are insurance and code requirements. Such authorities immediately indicate the deviation permissible from standard methods and code requirements; in particular, they ensure from X-ray and destructive tests that the processes and techniques adopted are satisfactory.

Neither gas welding nor resistance welding processes have found much scope in the welding of clad steels. On occasions the inert gas non-consumable electrode process has been used, but generally metal-arc welding is the most accepted method. With respect to the latter, there is no reason why automatic open-arc or submerged-arc processes cannot be used for welding the backing steel. As with manual metallic welding, however, a superior quality weld joint is obtained if the electrode is of the low hydrogen class.

Stress relieving of fabricated clad vessels is quite common, the time and temperature being dependent upon the composition of the plates. As stated earlier, heat treatment of the ferritic stainless steels involves dissipation of weld stresses and softening of hard zones adjacent to the weld, and 680 deg. C. is a typical temperature for such a steel. However, the austenitic stainless claddings are not normally stress relieved, since a careful balance has to be considered of the advantages gained opposed to ill-effects conferred to the resultant plate. In addition, whereas 850-875 deg. C. is an accepted temperature for the stress relief of 18/8 chromium-nickel steels, the same material when bonded to mild steel is only heat treated at 600-650 deg. C. This is something unavoidable when it is considered that the tensile strength of mild steel at 800 deg. C. would probably be about 3 t.s.i. Thus stress relief of a vessel would, at 850-875 deg. C., warrant exceptional support in the furnace, so much so as to make it impracticable.

Nickel and nickel-base claddings may be stress relieved at 620-650 deg. C., but we have seen what dangers can exist if a haphazard approach is made during heat treatment of this alloy. Probably more so than any other alloy, this material warrants careful control at all stages and only by rigorously adhering to such a policy will welded components be free of the phenomenon described earlier.

MAIN USES—Innumerable outlets exist for the use of alloy clad materials, the choice being a function of various factors. A clad steel may be selected because of economical reasons alone, availability in greater section thickness than the corrosion-resistant alloy or for the improved thermal conductivity. For the latter point it may be shown that the thermal conductivity of stainless steel is 0·05 cal./cm./sec./°C. However, the thermal conductivity of the same material in the clad form would be of the order 0·12 cal./cm./sec./°C. This improved figure is simply an arithmetical balance between the respective thicknesses of dissimilar metals.

Such benefits are not gained without cost. For example, the 18/8 chromium-nickel clad steels show the advantage of improved thermal conductivity, but since the coefficient of thermal expansion of 18/8 is nearly twice that of mild steel, the bond must be exceptionally good. The high quality of many commercial bonds has been proved by the wide industrial application of the steels, notwithstanding, in some instances, elevated temperature duties.

Chemical and petroleum plants are perhaps the two industries which have benefited most from the development of clad steels. Erudite engineers now accept the role these materials can play when designing fractionating towers, heat exchangers, storage tanks and other auxiliary equipment. When problematic situations arise concerning clad steels, the trouble may usually be attributed to an imbroglio of application or metallurgy of the subject.

The author wishes to thank the Directors of the Power-Gas Corp. for permission to publish this paper and to acknowledge with thanks the help and advice received from his colleagues.

CLADDING PRECIOUS METALS FOR BRAZING

NUMEROUS composites of silver- or noble-metal solder alloys clad to base or precious metal are now available in sheet, strip and foil. Fabricating parts from materials that have solder alloy pre-clad to the brazing surface eliminates the separate fabrication of small pieces of solder and the handling of these pieces during the brazing operation. The clad metal decreases the number of surfaces to be cleaned and fluxed, and also insures uniform wetting of the surfaces to be joined.

Silver-solder alloys containing various percentages (in relation to silver) of one or more of the following meet all usual solder requirements: copper, zinc, tin, cadmium, nickel, manganese, phosphorus and lead. Clad metals comprising noble-metal-solder alloys for all kinds of gold, platinum or palladium brazing are also produced, as well as special solder alloys for specific new applications.

In general, silver and other noble-metal-alloy solders can be clad on one or both sides of any base or precious metal in strip form. Parent metals frequently used include copper and copper alloys, nickel and nickel alloys, carbon steels and stainless steels.

Composites (other than the stainless steels) can be fabricated to 0·500 in. thick by 20 in. wide. Solder-clad stainless-steel maximum gauge is approximately 0·062 in. thick by 10-12 in. wide. Maximum and minimum limits are dependent upon cladding ratios, solder and base metal selection. Cladding ratios range from 5/95 to 70/30 for a single-clad material, and from 5/90/5 to 35/30/35 for a double-clad material. Temper depends on solder solidus. Tensile strength of a well-designed joint brazed with silver-solder clad metal may exceed the tensile strength of the metals that have been joined.

Average electrical conductivity of most silver-solder alloys range from 20-27 per cent I.A.C.S., although the silver-copper eutectic alloy (72 Ag-28 Cu) has a conductivity of about 77 per cent I.A.C.S., while that of tin-rich and phosphorus-containing alloys may be as low as 15 per cent I.A.C.S.

Solder-clad tubing and solder-clad and solder-cored wire are also being produced, according to Texas Instruments Inc.

USING MATERIALS FOR CUSHIONING

IN the past, cushioning and packaging have been an art rather than a science, but with the need to transport delicate and complex apparatus it is not surprising that the art is developing into a science, neither is it surprising that design criteria are being established for cushioning materials.

The range of materials which can be used includes rubbers, plastics foam, glass fibre-reinforced plastics and metallic and non-metallic honeycomb structures. A recent report[1] discusses the theory of cushioning design, criteria for designing suitable systems, their applications and economics.

From various experiments[2] aluminium honeycomb was found to have the most favourable ratio of density to energy absorption and showed no resilience. Glass foam showed no resilience and paper honeycomb almost none. The energy absorbed by foamed plastics over a density range 2-8 lb./cu. ft. appeared to depend on a power of the density, the exponent being approximately 2; cellular structure was not an important factor.

At impact a body is moving at a velocity ($V = \sqrt{2gh}$) and in a very short time after impact this velocity is reduced to zero in an infinitesimal distance. Thus, the rate of decrease of the velocity is very high, i.e., the body has been subjected to a high deceleration. Since force is a function of mass and deceleration, the effect of the impact is the development of a large force on the body.

Considering the same situation when the body is dropped on to a resilient cushioning material, the time required for the velocity to be reduced to zero is much greater than in the previous situation, i.e., the rate at which the velocity decreases is considerably less. Compared with the first situation the body is subjected to low deceleration, hence the force imposed on the article is reduced.

The body at impact has a kinetic energy (K.E. $= \frac{1}{2}$ mv^2) which must be absorbed by the resilient cushion or material. To apply cushioning materials to secure a desired cushioning effect, it is clear that the energy-absorbing characteristic of the material must be known. This characteristic is determined from the stress-strain curve for the material, and the area under this curve at any value of strain represents the energy absorbed or stored by the cushioning material.

Mathematically it was shown that

$$G = \frac{h}{t}\left(\frac{f}{e}\right)$$

where G = number of accelerations;
h = height of drop, in.;
t = thickness of the cushioning, in.;
f = dynamic stress, p.s.i.; and
e = energy absorbed by cushioning material, in. lb./cu. in.

Where the ratio $\left(\frac{f}{e}\right)$ is at a minimum it may be stated that the material is being utilised at maximum efficiency.

One particular physical property of interest is the creep or cold-flow characteristics. When any weight is placed on a cushioning material, the material will deflect a certain amount in a very short time, as can be determined from a static stress-strain curve for the material. If the load remains on the cushion which is analogous to the situation in a package, the cushioning material will continue to deflect until an equilibrium is reached. The time required to attain the equilibrium varies with different materials. This continued deflection with time is termed the creep or cold flow. The amount of cushioning required as calculated from the acceleration static stress curve must be augmented to compensate for the amount of creep that will occur.

Cushioning materials exhibit varying degrees of creep, the data indicating that the degree of creep depends upon each manufacturer's formulation or the nature of the specific supplier's product.

$$\% \text{ Creep} = \frac{\text{Thickness after 3 min. of loading} - \text{Thickness after 1 week of loading}}{\text{Thickness after 3 min.}} \times 100$$

Acceleration static stress data were determined experimentally for various thicknesses of several polyurethane and fibrous glass materials and from an examination of these data an empirical formula may be derived to predict curves for different thickness from an established curve for a 2-in. thickness of material.

How to Design the Cushioning

The following data are available for design purposes:

1. Fragility or desired maximum accelerations.
2. Static stress-strain curve.
3. Height of drop.
4. Acceleration static stress curves.
5. Creep characteristics.

From the fragility and static stress involved, the thickness of the cushioning material is determined from the acceleration static stress curve. This thickness must be adjusted to account for the strain due to the static load and the creep.

Algebraically it can be shown that the required thickness may be determined directly by dividing the thickness determined from the acceleration static stress curve by the factor (100 − % creep)

$$\text{e.g.: } \frac{6}{100 - 0{\cdot}30} = 8{\cdot}5 \text{ in.}$$

In selecting the proper material to cushion various delicate articles, there are other considerations in addition to determining the thicknesses of cushioning material required in the various packages.

Some of these other important factors are material density, material cost and shipping costs for the packages utilising the cushioning material. The selection of the cushioning material may be determined by application of the following formula:

Total cost of using a specific cushioning material

$$= C_m = TDA\left(\frac{\text{Cost Material}}{\text{per Pound}} + \frac{\text{Cost Freight}}{\text{per Pound}}\right)$$

where T = thickness of cushioning, in.;
D = density of cushioning material, lb./cu. ft.; and
A = area of cushioning material, sq. ft.

Cushioning design can be accomplished on a rational or engineering basis, provided certain significant properties are known and the behaviour of the cushioning material under dynamic loading is understood.

All cushioning materials with non-linear behaviour function most effectively or efficiently for a specific static stress or a range of static stresses which can be designated as the optimum point or range. At the optimum point or range the acceleration will be minimal or the ratio of the dynamic stress to the energy absorbed per unit volume will be minimal.

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STRETCHED ACRYLIC SHEET

Stretching has been found to enhance the impact strength and other properties of acrylic sheet. The reduction of weight possible and other effects of this technique are described here

by J. W. LADBURY, B.Sc., Ph.D., D.I.C., A.R.I.C. *

IT was discovered during the last war that polymethyl methacrylate aircraft canopies which had been subjected to a large amount of stretching in their manufacture had superior resistance to fracture compared with canopies of similar thickness in which less stretching had occurred. After the war investigations were made,[1, 2, 3, 4] both in England and the U.S.A., into the mechanical behaviour of stretched acrylic. It was discovered that an enhancement of properties, such as craze resistance, impact strength, etc., occurred in the direction of uniaxial stretching, but a deterioration in those properties was found in a direction at right angles to the stretch direction. When the material was made to undergo homogeneous strain an improvement took place in those properties in all directions in the plane in which the sheet had been stretched. This improvement in essential properties has allowed windows of reduced weight to be used in aircraft with a resulting increase in payload. Biaxially stretched acrylic is now used extensively in windows of U.S. aircraft and is likely to be applied in civil aircraft glazing in this country.

Theoretical Considerations

The improvement in essential properties when acrylic sheet is stretched and the change from an isotropic to an anisotropic laminar structure is caused by the orientation of the molecules brought about by stretching. When the material is hot stretched the distance between the polymer chain ends increases and the polymer chain segments tend to be brought into the plane of the sheet. The strength of a solid depends on the magnitude of the cohesive forces between the ions, atoms or molecules and the efficiency with which the structure of the solid makes use of them. Intramolecular satisfaction of cohesive forces contributes nothing to the strength of the material, but if the polymer molecules are extended from their coiled conformations, these forces become intermolecularly satisfied and more efficient use will be made of them. Solids are generally weaker than their calculated strengths because of the presence of submicroscopic flaws. When a solid is subjected to a tensile force, stresses can concentrate in the worst flaw which is suitably oriented and which then becomes enlarged.

Crazing is the occurrence under the influence of stress of small visible cracks with the major axes of the cracks at right angles to the direction of the applied force. It is the visible result of the opening by the action of stress of submicroscopic flaws. The stress may be externally applied or "frozen-in". When stress is frozen-in, it is only where there are inhomogeneities that crazing occurs; there must be adjacent regions of high and low stress where the high stress can relieve itself in the low stress area. The effect of solvent on the surface of the material is to produce, by adsorption at the tip of the flaw, swelling which increases the strain energy in that region and also separates the molecules so that the forces acting between them are decreased. The result is that a smaller stress is required to promote crack growth. Uncoiling of the polymer chains, by allowing a more efficient use to be made of the cohesive forces, brings about a reduction in number and extent of the weak areas. It is evident that more work must be done to open up a crack, and the probability of a crack being suitably oriented will be smaller. Hence more force will be required to cause crazing either by force acting alone or combined with the swelling and plasticising action of a solvent.

Further, as a result of the diminution in the number and extent of the submicroscopic flaws, tensile fracture will occur at a later point along the stress-strain curve. There is little difference in the early parts of the curves for biaxially stretched and unstretched acrylic sheet; i.e., there is little change in Young's modulus when the sheet is biaxially stretched.

The effect of bringing the chains into the plane of the sheet is to decrease the strength perpendicular to that plane with the result that the shear strength in the plane of the sheet is reduced when it is biaxially stretched; the structure is similar to, but less pronounced than, that of mica. Similarly, the force holding a piece of the surface to the bulk of the material is decreased as a result of stretching, and if this piece is separated from the rest of the surface it will become detached from the bulk more easily. This means that there is a reduction in abrasion resistance.

* *Technical service and development dept., I.C.I. Ltd. Plastics Division.*

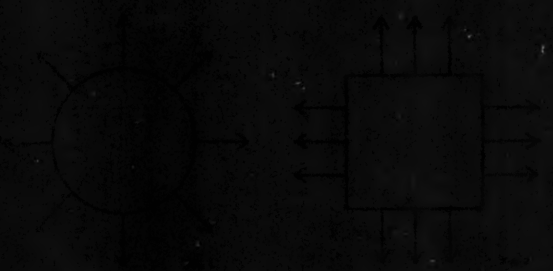

Fig. 1. Disposition of forces in multiaxial stretching.

Fig. 2. Disposition of forces in biaxial stretching.

Fig. 3. Eccentric roller type of clamp (initial clamping arrangement omitted).

Fig. 4. Wedge type of clamp (initial clamping arrangement omitted).

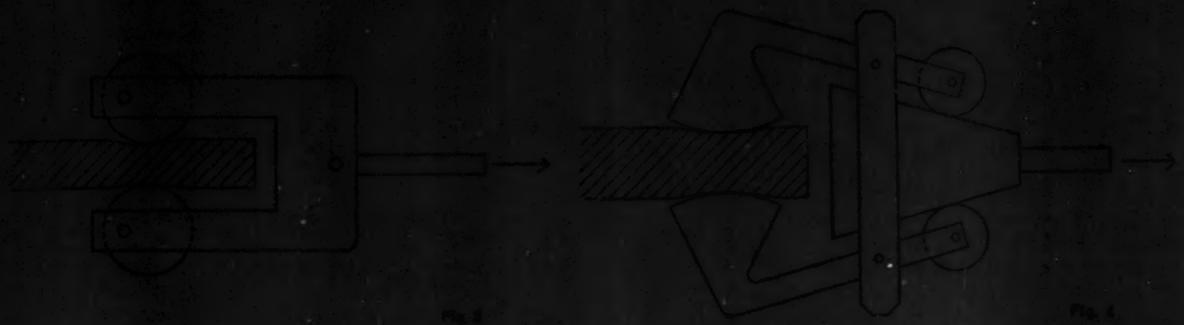

Fig. 3

Fig. 4

Stretching Procedure

There are two methods presently used to bring about homogenous strain, the so-called biaxial and multiaxial stretching processes. The difference between the two methods is simply one of mechanical procedure, the distortions in the polymer molecules (in the region away from the edges where the material is clamped) being the same, for the same degree of stretch, with both methods. Hence there should be no difference between the basic properties of multiaxially and biaxially stretched acrylic, and there is no evidence to show that any difference exists.

With the biaxial stretching technique a rectangular sheet is clamped along its four sides, two adjacent sides being held to stationary crossheads and the sides opposite to these being fixed to movable crossheads. The movable crossheads can travel together or independently, at the same or different speeds. With the multiaxial stretching process, the extending forces are applied along the radii of a circle in the plane of the acrylic sheet.

The acrylic sheet is stretched in the temperature range 130-160 deg. C., the temperature used depending on whether the material is normal, plasticised or crosslinked and, to some extent, on the thickness. The optimum temperature for standard Perspex acrylic sheet is 140 ± 5 deg. C.

The major problem in the construction of the stretching apparatus is the design of the clamps. The forces acting on the edges of the sheet are considerable and, for 100 per cent stretch, are in excess of 500 p.s.i. of area of side, the actual figure depending on the material and temperature. Such forces are sufficient to overcome the initial frictional forces between the clamp jaws and the sheet and it is necessary to translate some of the lateral force into pressure exerted by the jaws. This can be done by using eccentrically-mounted, knurled rollers as the jaws of the clamps. The lateral forces cause rotation of the cams and increase the grip on the sheet. Alternatively, the jaws may be at ends of levers which are pivoted so that the other ends rest on the sloping sides of a wedge attached to the crosshead. When the stretching force is applied, the ends of the lever touching the wedge take up positions farther up its slope and the jaws are pushed together.

It is also necessary to cool the clamps in order to increase the strength of the acrylic sheet in the clamping region. The temperature of the sheet in and around the jaws of the clamps must be neither too high nor too low. The sheet tears if it is too high, and cracks if it is too low. Clamp temperatures in the region of 90 deg. C. are satisfactory, but the time during which the clamps are cooled should not be longer than that necessary to cool the material in the immediate vicinity of the clamps.

Biaxially stretched acrylic sheet for small-scale testing can be made by the method described by Barker and Birley[1] in which a hot acrylic sheet is sucked through a hole to form a segment of a sphere and then allowed to "snap back" on a circular former by releasing the vacuum.

Degree of Biaxial Stretching—If it is assumed that no or little volume change occurs on stretching and the original dimensions are a_1, b_1 and t_1, and final dimensions are a_2, b_2 and t_2, where a and b are the lengths of the sides and t is the thickness, then the percentage linear stretch (p) is given by:

$$100 \times \frac{(a_2-a_1)}{a_1} = 100 \times \frac{(b_2-b_1)}{b_1} = p$$

if the rates and times of draw are the same for both crossheads.

$$\therefore \frac{a_2}{a_1} = \frac{b_2}{b_1} = 1 + \frac{p}{100}$$

then because $a_1\, b_1\, t_1 = a_2\, b_2\, t_2$

$$\text{we have} \qquad p = \left\{\sqrt{\frac{t_1}{t_2}} - 1\right\} \times 100$$

Properties of Stretched Acrylic Sheet

Crazing—Biaxial stretching considerably increases the resistance to crazing by both stress alone and stress and solvent combined. For instance, while unstretched acrylic sheet will show crazing in ten days under sufficiently high applied stress, sheet which has been stretched 100 per cent in each of two directions at right angles, when subjected to the same stress, requires more than twenty-five days for crazing to appear. Again, material which has been stretched 100 per cent along each of two axes at right angles requires

an outer fibre stress (which is applied by loading a beam of the material at one end while it is clamped at the other) about three times greater than that required by unstretched sheet in order to develop the same extent of crazing induced by painting the upper stretched surface of the beam with isopropyl alcohol.

IMPACT STRENGTH—Biaxially stretched acrylic sheet has a much greater impact strength, as measured by the Izod, falling missile, etc., tests, than unstretched sheet. The best way to exemplify this is to describe the results of the repeated falling missile test. The procedure is to allow a 100-g. missile whose nose has a radius of ½ in. and whose weight is increased by 25 g. after each impact to fall from a height of 3 ft. on to a clamped circle of ½ in. thick material of 3 in. diameter. While unstretched Perspex fractures at about 250 g., sheet which has undergone a 75 per cent biaxial stretch fractures at about 750 g. Furthermore, the type of fracture differs in the two cases; when unstretched material suffers impact a star-shaped crack is obtained, while with stretched material a laminar shattering takes place. This difference in behaviour is associated with another property which is improved when acrylic sheet is biaxially stretched; viz., the crack propagation resistance.

CRACK PROPAGATION RESISTANCE—Energy must be expended in order to propagate a crack. This energy is used in creating new surfaces and in plastic deformation at the tip of the crack. It is likely that there is some degree of correlation between the energy required to propagate a crack and the energy needed to initiate a crack. The initiation process is, according to Griffith,[5] the enlargement of a submicroscopic flaw, caused by stress concentration at its apices, and initiation differs from propagation only in the size of the original flaw. It is to be expected then that the crack propagation resistance should be closely related to the impact strength. While the conventional impact strength tests merely give indications of suitability which are not very satisfactory as the basis for design considerations, measurement of the crack propagation resistance by a method such as that described by Benbow and Roesler[6] gives a more realistic appraisal of the toughness of the material.

The work necessary to propagate unit area of crack is considerably greater, five or six times as great, for biaxially stretched acrylic than for unstretched sheet. The importance of this improvement lies in the greatly decreased risk of catastrophic depressurisation if a stretched acrylic window of a high-flying aircraft is fractured as a result of local and temporary overstress.

TENSILE STRENGTH AND STRAIN AT FAILURE—Biaxially stretched sheet has a somewhat higher tensile strength than unstretched sheet, but this difference is small at low testing speeds. When tested at a speed of 10^{-3} in./sec. at 20 deg. C., biaxially stretched Perspex yields before breaking with a yield stress about 20 per cent greater than the peak stress of unstretched sheet, which, as often as not, breaks before yielding. However, the improvement in tensile behaviour brought about by stretching is reflected more in the strain at failure which is increased by a factor of about four when Perspex is 100 per cent biaxially stretched. This is linked to the improvement in impact strength. The energy absorbed up to fracture is given by the area under the stress-strain curve and this area is increased by hot stretching the acrylic sheet, although the increase falls off somewhat with increasing speed of testing. None the less, this area must still be larger for biaxially stretched material than for unstretched sheet at testing speeds which give test durations of the same order as impact times.

SHEAR STRENGTH—The shear strength in the plane of the sheet is decreased when acrylic sheet is biaxially stretched. This is due to the laminar structure of stretched acrylic sheet, which was discussed earlier.

ABRASION RESISTANCE—This property also deteriorates when the material is biaxially stretched for the reasons given earlier, but the deterioration is slight.

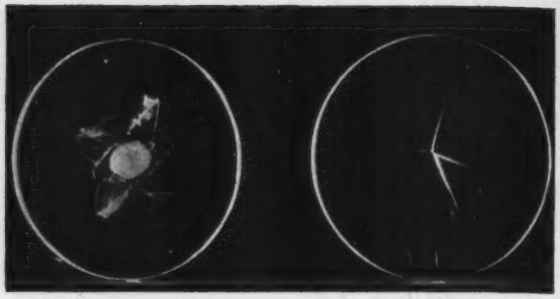

Fig. 5. Fracture on impact of (left) biaxially stretched Perspex acrylic sheet and (right) standard sheet.

Fabrication Processes

Because of the frozen-in stress, there is obviously a very strong tendency for biaxially stretched acrylic to revert to its original dimensions when heated. This tendency is negligible below 80 deg. C., but increases rapidly above 110 deg. C. Because of this possibility of reversion at elevated temperatures, fabrication procedures must be modified for biaxially stretched material.

SHAPING—Single curvatures can be easily formed from flat stretched sheet by loading the edges with about 20 p.s.i. of area of side and heating on a former with the required curvature at 110 deg C. for about 2 hr. Longer times and heavier loading may be required depending on the degree of curvature, but never should the temperature be increased much above 110 deg. C. For multiple curvatures a similar technique is applied using both a male former and female tool which are clamped together with the sheet between them.[7] With shapings which involve considerable deformations, it is possible to combine the deformation required with the stretch.[8, 9]

CUTTING—Stretched sheet can be cut, in the same way as is normal for standard material, on a band saw having ten teeth to the inch and a speed of 7,000 ft./min.

DRILLING—There is a tendency for biaxially stretched sheet to chip at both top and buttom surfaces near the edge of the hole. It is possible to drill a hole with clean edges if the stretched sheet is bolted between two sheets of standard material. A slow feed to the drill should be used and there should be no rake to the drill. For a ¼-in.-diameter drill a speed of about 600 r.p.m. should be used. The presence of swarf around the hole tends to cause overheating and consequent thickening of the material at the edge. This difficulty can be overcome by using oil as a lubricant or compressed air to remove the swarf.

ROUTING AND SPINDLE MOULDING—So long as the cutter is at right angles to the plane of stretching, there is no difference between the behaviour of biaxially stretched and standard material to these two operations.

EMERY WHEEL AND LINISHING—There is a tendency for these two operations to cause overheating and consequent thickening in the areas which are being treated.

POLISHING—A good surface can be obtained on biaxially stretched sheet using first a buffing soap on an 8-in.-diameter buff at 3,000 r.p.m. and then using a buff, rotating at a similar speed, but without soap.

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designer's notebook

Temperature Detection in High Pressure Fluid Piping

A METHOD of following temperature changes in fluids passing through heavy-walled piping, with a sensitivity comparable to the familiar protruding well-type detectors used in low-pressure piping, but without the need for protrusion into the fluid, is described in a recent paper to the A.S.M.E. by D. Robertson. The method was investigated in order to find a method of avoiding the use of thermowells which, in a highly stressed pipe, were clearly undesirable.

The method described employs a special thermocouple which is diagrammatically shown in Fig. 2. It will be seen that this thermocouple has three junctions, two of which (b_1 and b_2) are situated at point B, the third junction (c) being farther away from the centre of the pipe at point C.

The temperature detector works on the following principle. If a curve of temperature versus time were plotted for each of two points at different distances from the outside of the pipe, the two curves would start from the same point, diverge until a maximum temperature difference was reached, and then would converge and finally meet when equilibrium was reached again. The time required to reach a maximum deviation between the curves is a function of the size and material of the pipe and the location of the temperature points, but is independent of the magnitude of the temperature change.

If therefore a detector, indicating temperature B, such as that shown in Fig. 2, had its signal altered by the temperature difference between B and C in the proper direction, a response curve such as B-C (Fig. 1) would result. This curve represents a sensitive indication of dynamic temperature conditions inside the pipe and is obtained without insertion into the flowing medium.

Considering the three-junction thermocouple in Fig. 2, when the temperature of B is above C, the e.m.f. from this couple is positive at b_1 and negative at b_2, which adds to the voltage of the fundamental couple. Junction C is therefore the difference junction. If the temperature change is in the opposite direction, the difference signal will change polarity and make the system reversible.

(Abstracted from A.S.M.E. Paper No. 59-A-201)

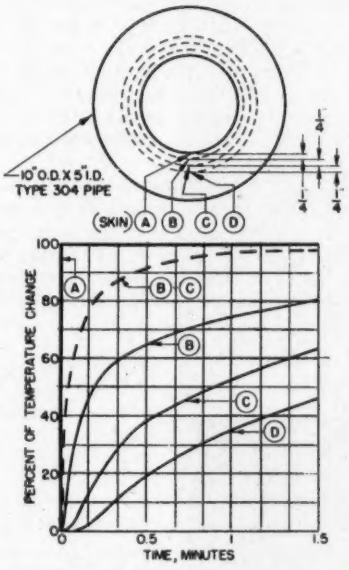


Fig. 1. Calculated thermal response of a pipe wall to an inside surface step-temperature rise.

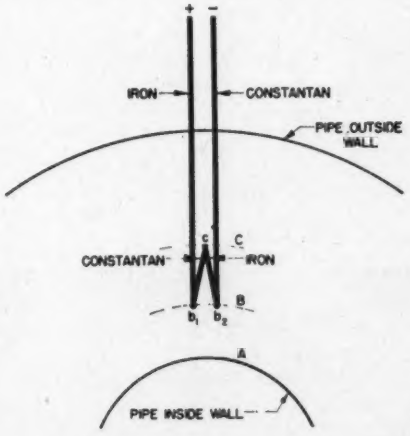
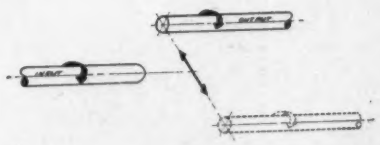


Fig. 2. Composite thermocouple.

PROBLEMS IN DESIGN

Here is this month's problem, set by R. E. W. Baker:

Input shaft to drive output shaft in the same direction and at the same speed as its own. Output also to reciprocate radially in a straight path at one complete reciprocation per revolution of shafts.



Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12×12in., please!), to The Editor, "Problems in Design No. 8 (June)". Closing date July 11.

designer's notebook

PROBLEMS IN DESIGN

Problem No. 5 (March).

In a knot-tying machine it is necessary to provide a means whereby (by the pressing of a button to operate an electro-mechanical clutch, or by the operation of a lever) a shaft on the same axis as that of the power source, an f.h.p. motor, is caused to rotate exactly one revolution and then stop; the output shaft speed to be approx. 1/10 of the input motor shaft. The input motor shaft runs continuously. Direction of rotation of the output shaft can be the same as the input shaft or in the opposite direction. If it is decided to use a standard motor and clutch unit, details of the clutch need not be shown. Mechanical braking of the output shaft is not permissible.

Of the entries submitted for our March problem, we consider that from J. Pooley (Fig. 3) to be the best, as it incorporates in one unit, without the use of a slipping clutch, both the reduction gear and the one-revolution indexing mechanism. It works as follows:

The mechanism uses a 10:1 epicyclic reduction gear train with a spring-loaded bell crank lever (C). The arm of the bell crank lever is shaped so as to engage with a ratchet ring on the annulus (F). A second arm (B) of the bell crank lever is shaped so as to engage a vee-slot on the circular plate (E), which is integral with the planet carrier.

The f.h.p. motor drives the input shaft (J). When the mechanism is not being operated, the input shaft merely rotates the annulus (F) via the planet gears (H), and no torque is transmitted to the output shaft (G) of which the planet carrier forms a part. In this state the lever arm (B) is held by the torsion spring (D) so as to engage the vee-slot, as shown in the left-hand view.

When, by means of a lever, cam or other means, the tip of arm (A) is made to engage the ratchet, the drive and, at the same time, the tip of arm (B) is caused to move for sufficient time for its tip to be trapped by and run around the now rotating planet carrier (E). On the completion of one revolution of the output shaft, the tip of arm (B) re-engages the vee-slot, at the same time as arm (A) disengages the annulus.

G. T. Dormer (Fig. 1) employs an electro-magnetic clutch operated by a micro-switch to initiate rotation of the output shaft. Indexing is effected by a lever, the rounded end of which engages a dimple or depression in a rotating plate on the output shaft. The only possible weakness in this simple solution would appear to be the danger that, with wear or poor workmanship, the micro-switch might operate slightly before in starting, or after in stopping, and so give rise to undesirable bending of the indexing detent.

The entry submitted by J. Tindale (Fig. 2) is perhaps the most thought-provoking (we certainly found it so!) for, although it is rather complicated, it contains certain refinements which might be very useful in such a one-revolution indexing mechanism.

With the output shaft stationary, the spring clutch is slipping and at rest. When the shift lever is released, the clutch then drives the spring capstan and hence the output shaft. The feed back to the differential gives an output of 1 rev. to the differential for 10 revs. of the input shaft. As the feed-back shaft makes 4 revs. to 1 rev. of the output shaft, the input lever arm fouls the auto cut-off at precisely 1 rev. This action unwinds the spring from the 10-rev. drum and so prevents further transmission of power. The clutch slips and the differential output wheel rotates against it at a speed of 5 revs.

The elegance of this mechanism lies in the fact that only one-fifth of the total torque is used up in restraining motion of the output shaft during non-operation periods. By increasing the number of turns of the capstan wire, larger output torques can be obtained with no increase of input torque, with a resultant increase in efficiency.

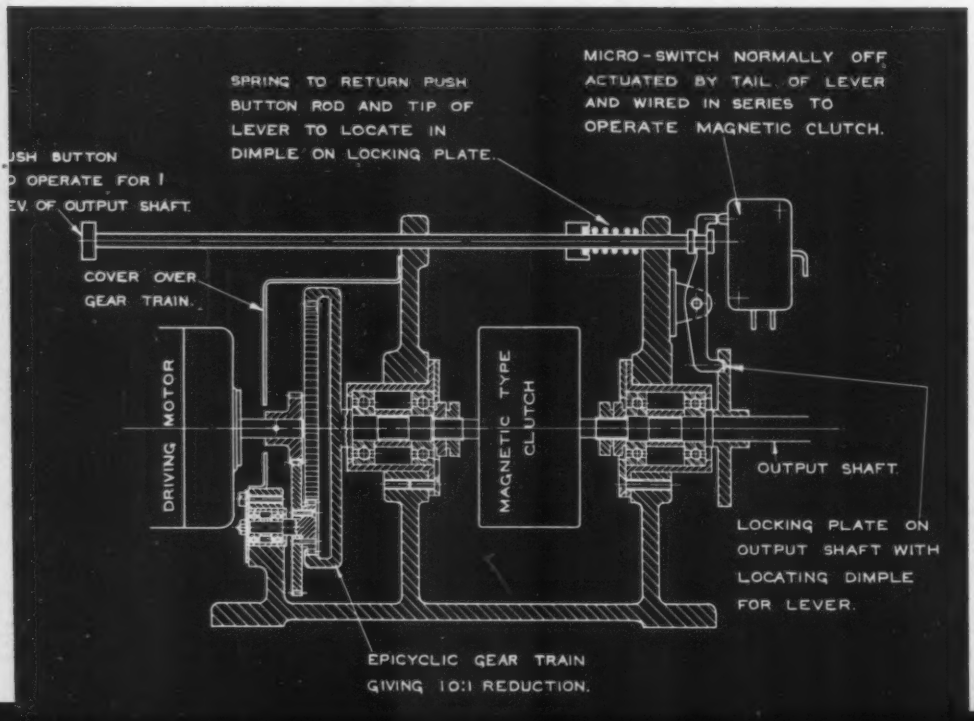

SPRING TO RETURN PUSH BUTTON ROD AND TIP OF LEVER TO LOCATE IN DIMPLE ON LOCKING PLATE.
MICRO-SWITCH NORMALLY OFF ACTUATED BY TAIL OF LEVER AND WIRED IN SERIES TO OPERATE MAGNETIC CLUTCH.
USH BUTTON
O OPERATE FOR 1
EV. OF OUTPUT SHAFT.
COVER OVER GEAR TRAIN.
DRIVING MOTOR
MAGNETIC TYPE CLUTCH
OUTPUT SHAFT.
LOCKING PLATE ON OUTPUT SHAFT WITH LOCATING DIMPLE FOR LEVER.
EPICYCLIC GEAR TRAIN GIVING 10:1 REDUCTION.

Fig. 1. G. T. Dormer. Solution uses electro-magnetic clutch operated by a micro-switch.

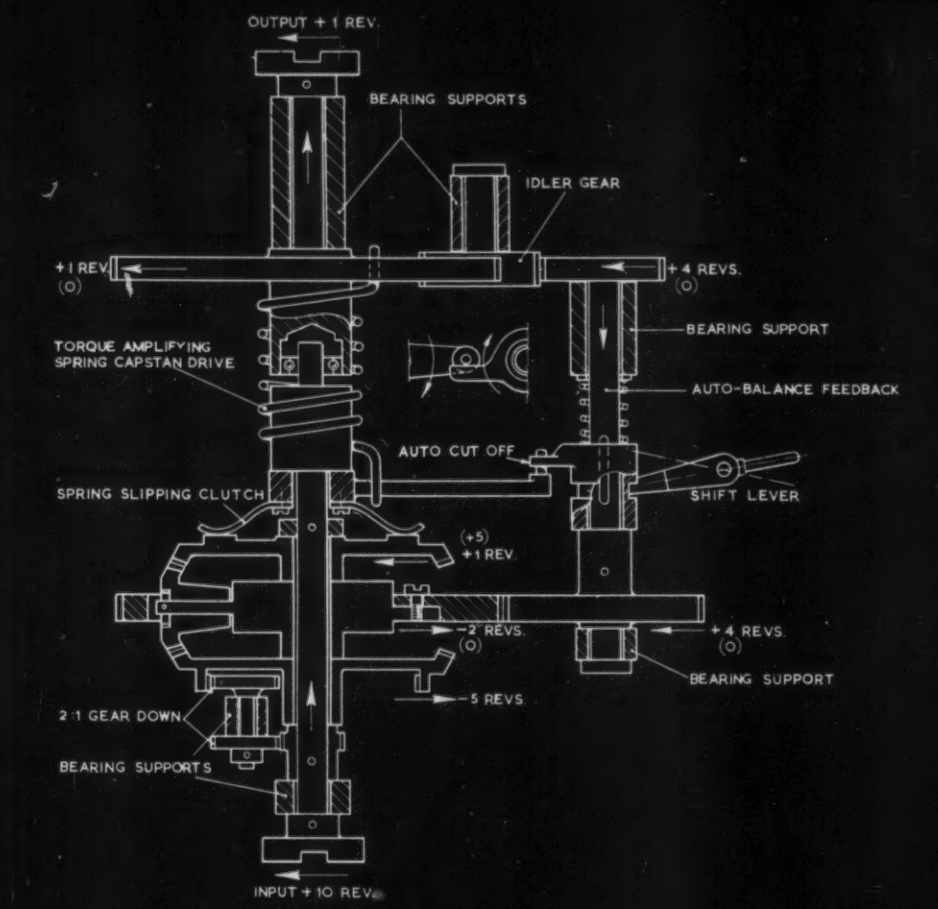


Fig. 2. J. Tindale, M.I.Mech.E. An ingenious solution using positive feed-back gear train and a torque amplifier.

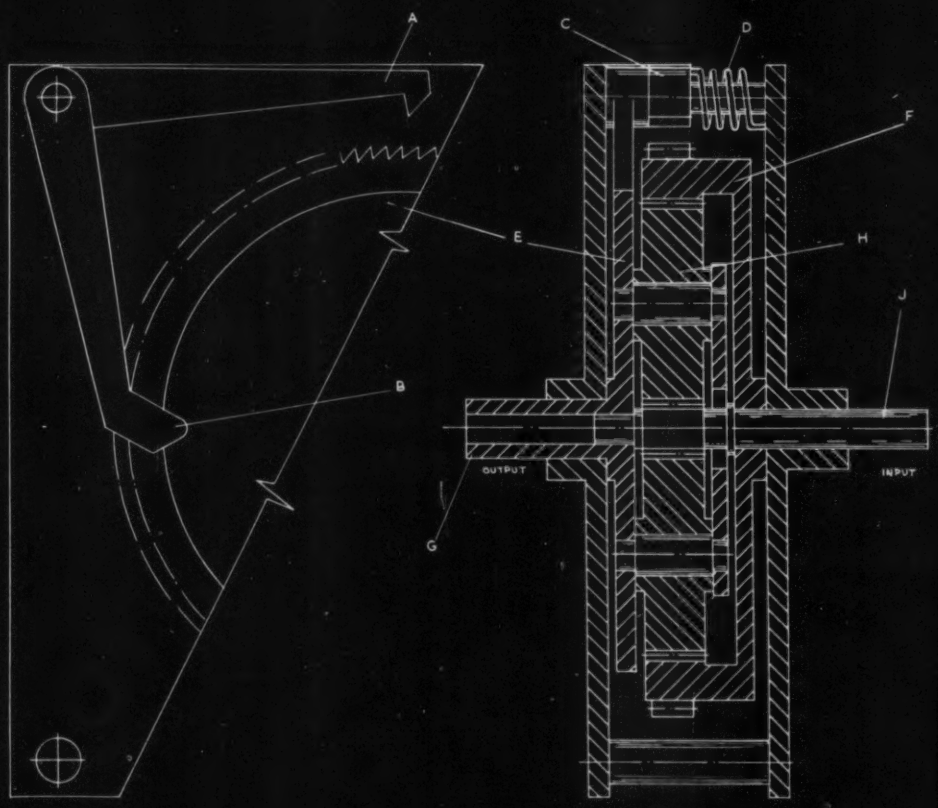


Fig. 3. J. Pooley. A compact mechanism using an epicyclic gear train. When bellcrank lever (C) engages ratchet wheel, second arm (B) is disengaged from planet carrier (E) for one rev. only.

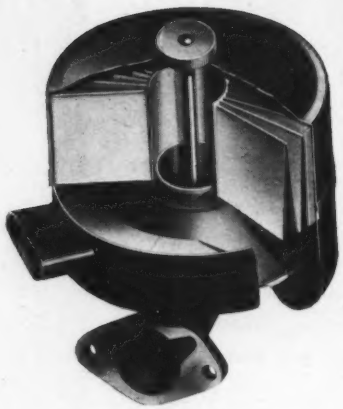


Fig. 1. Section through Purolator Micronic dry-type oil filter with pleated paper element.

FLUID CLEANING AND FILTRATION

This article describes the various methods of cleaning fluids such as lubricating oils, engine fuels and hydraulic liquids, and their application to prevent wear and corrosion

by K. E. NICHOLDS, A.M.I.Mech.E.

SOME kind of filter is provided in a wide variety of machines and equipment. Published literature on filters is sparse, although a large amount of research has been carried out on the problem of separating the wanted and unwanted constituents of a fluid. The user has to rely on manufacturer's performance data and as the performance of a filter is difficult to define, dissatisfaction often arises as a result of misinterpretation. This article provides as concise a picture of the problem and methods of solution as possible.

There are three main reasons why it is desirable to remove contaminant:

1. To reduce wear.
2. To prevent jamming of controls.
3. To reduce corrosion.

WEAR—Given the proper choice of sliding pair materials and correct lubrication, mechanical wear can only be caused by the cutting action of hard particles dragged over a surface. It is necessary that the particles be forced against the abraded surface for wear to take place, and this is generally due to the bearing load between sliding surfaces.

An exception is wear caused by erosion, due to the kinetic energy of particles in a fluid stream impinging on a wall. An example of this is in atomising nozzles, where erosion can alter the nozzle characteristic and the shape of the jet.

In order that the particles causing wear between sliding surfaces can be present, they have to be small enough to enter the working clearance and large enough to be in contact with both surfaces at the same time. This is thus theoretically an optimum size for wear-causing particles for a given clearance, but as the clearance generally varies, it is concluded that all particles cause wear, although most wear may be caused by a certain size in a particular application.

In general, dirt particles vary in size and shape. The size is usually measured in microns (1 micron = 10^{-6} metre = 10^{-3} mm. or 1/25·4 part of a "thou"). If a range of particle sizes is present naturally, the size distribution is smooth and generally bears some relation to a normal distribution curve (see Fig. 2).

JAMMING—Fluid control mechanisms, particularly servo mechanisms, are generally sensitive to dirt, because of fine clearances and small forces. Jamming is often accentuated by silting up of the clearance by small particles, forming a tightly-packed bed.

CORROSION—The process is exemplified by consideration of what can happen in an engine oil. The effect of dirt is to cause mechanical wear, resulting in increased bearing clearances but in closer running clearances.

An increased bearing clearance implies that larger particles can get between sliding surfaces, and closer running clearances increases the jamming effect (as in a plain journal)

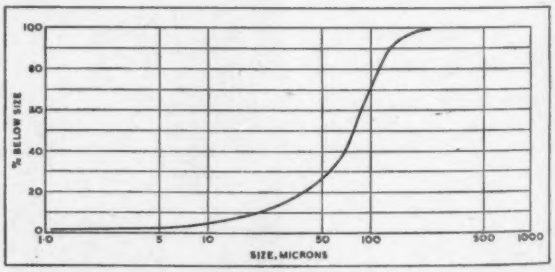


Fig. 2. Typical particle size distribution curve.

TABLE 1. Properties of common filter media

Material	Min. Nominal Cut-off Size	Relative Pressure Drop	Relative Cost	Relative Strength	Temp. Limitation
Wire gauze	0·0015 in.	Low	High	High	Melting point of material
Edge-on metal plates	0·0005 in.	Low	High	High	"
Edge-on paper discs	1 micron	High	Low	High	120°C.
Cloth	0·002 in.	Low	Medium	Low	120°C.
Felt	25 micron	Medium	Medium	Low	120°C.
Filter paper	5 micron	High	Low	Low	150°C.
Ceramics	1 micron	Very high	Low	High	1,000°C.
Porous plastics	1 micron	Very high	Low	Low	80°C.
Sintered metal	1 micron	High	High	High	Melting point of material

and raises the oil temperature. In turn, this reduces the running clearance and so on. The net result is a cumulative wear effect, and eventually the combustion products find their way into the oil and oil finds its way into the combustion space. Hot gases in the oil result in oxidation and by-products; oil in the combustion chamber burns to carbon and tends to raise the combustion temperature. This raises the rate of reaction between the oil and the hot gas. Again, this is a cumulative process, but it is the acid by-products which cause corrosion.

There are three main methods of removing dirt:

1. By settling.
2. By filtering.
3. By magnetic or electrostatic attraction.
4. Inertial separation.

Settling

This is a gravitational process. Provided the dirt particles are not so small that their motion is influenced by random movement of the molecules in the carrier fluid (Brownian movement), they will settle at a rate given by Stokes equation,

$$\text{Velocity} \propto \rho \frac{d^2}{\mu}$$

where ρ = density; d = particle size; μ = viscosity. (exactly for a sphere, approximately for an irregular shape). Thus if fluid takes long enough to pass between two points the dirt will have time to settle. Settling rate may be increased by an artificial increase in "g", as in a centrifuge or a cyclone. The settling rate may also be increased by increasing the size of the particles by agglomeration caused by ultrasonic sound generators.

Filtering

Filtering is essentially a screening process: what is important is that a screen will stop particles *smaller* than the pore size in the screen. Considering a wire mesh as a filter model, it is obvious that it will remove from a fluid flowing past it particles whose smallest dimension is greater than the pore size; it is also obvious that particles whose shape is needle-like will be removed if they arrive at the screen long side on. Consideration of the stream lines around the screen elements and the trajectory therein of a particle shows that once within a limited area upstream of the element a particle will impinge on the element and be held there, certainly by the force of the stream and, it is thought, by attraction between particle and element. The chance of this happening depends on stream velocity, element size, element pitch and particle size. It should be noted that the word "chance" is not used here idly. Filtering or separation in any form is a probabilistic process, a fact which tends to confuse users. This is enlarged on later.

EFFICIENCY OF FILTER—The efficiency of a filter, defined as $1 - \frac{\text{number of emergent particles,}}{\text{number of incident particles}}$ is $1 - e^{rh}$

where $r = -\left[\frac{c}{1-c} \cdot \frac{2}{\pi R}\left(\frac{x}{R} + \frac{\nu}{\pi q}\right)\right]$

c = packing density of filter,

i.e. $\frac{\text{true volume of filter}}{\text{apparent volume of filter}}$

R = element radius;

$2x$ = width of band in which interception is inevitable, (a function of v, R, viscosity, particle size and mass);

ν = viscosity;

q = mean velocity;

h = depth of filter in direction of flow.

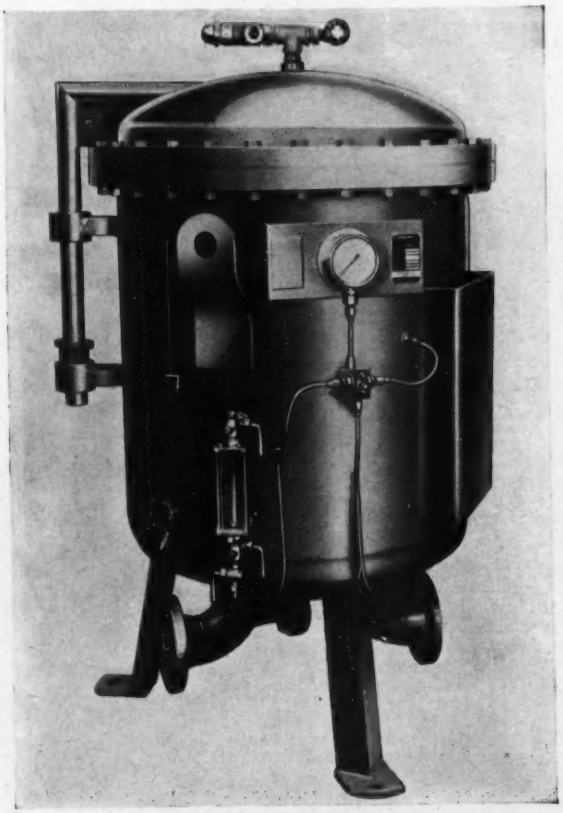
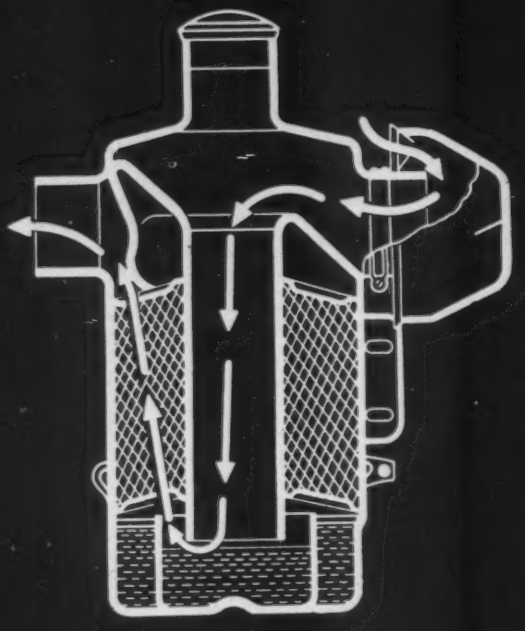
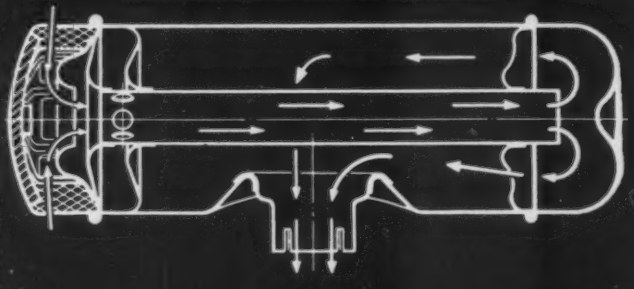
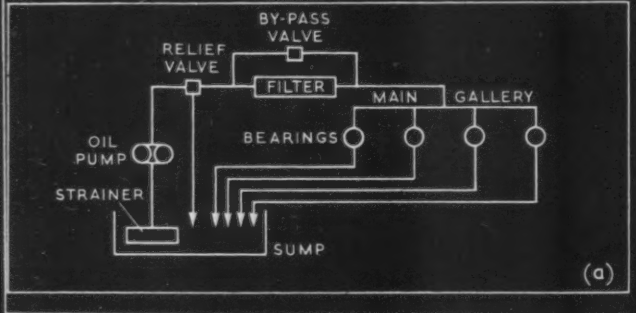
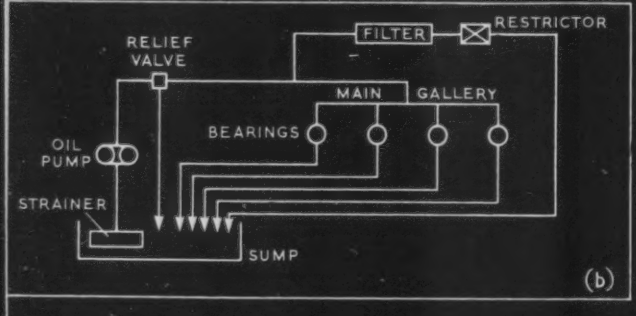


Fig. 3. Bulk fuel filter and water separator by Automotive Products for aircraft fuel cleaning.









Thus increased efficiency follows from (a) increased packing density, (b) increased depth, and (c) lower mean velocity of the stream.

In practice, as the distribution of particles in the stream is random and the majority of filter materials (except wire screens and the like) have a random pore size, the efficiency is such that a very sharp cut-off is never obtained.

Thus to speak of a 5-micron or a 10-micron filter as one which will positively remove *all* particles greater than the size stated is erroneous; what is meant is that the probability of getting particles through a filter of the class quoted larger than the nominal cut-off size is small.

The efficiency of all filters is initially poor; as dirt is removed, a filter bed is formed by the collected particles which enhances the efficiency at the expense of increased pressure drop. Ultimately, the pressure drop is so great that the flow is reduced to an unacceptable level: the filter has choked. Choking may also be caused, particularly in aircraft fuel filters and C.I. fuel filters, by wax and ice.

FILTER MATERIALS—A filter material has to compromise between high efficiency, low pressure drop, cheapness, consistent performance and robustness. It is usual to pleat the screen in order to pack the greatest area with the smallest volume, thus reducing the velocity to increase efficiency and increasing the area and hence the life to choke at the same time. Table 1 shows the commoner filter media, with their properties.

It will be seen that metallic screens offer a relatively poor degree of protection, but they give a uniform performance, A better efficiency is offered by cloths, felts and papers, but owing to the nature of the material the uniformity of pore size is not so good. This is partially offset by the greater depth of material usually employed. Very fine filtration can be obtained by using sintered powders, either metallic or ceramic, or porous p.v.c., similar to battery plate separators. The uniformity is good, but the pressure drop is high.

Magnetic and Electrostatic Separators

Magnets in a fluid can be used to collect ferrous and other paramagnetic particles. Inevitably, non-magnetic particles are drawn in with the magnetic ones, and held by being intimately associated with them. Similar laws apply to magnetic separators as to gravitational separation, i.e., the particles in a fluid stream flowing past the magnet are attracted towards it (in this instance the inverse square law governs the attractive force). Depending on their initial distance from the magnet and their velocity, they may drift across the stream lines to the magnet before they have moved out of the magnetic field.

Electrostatic precipitators are generally used only for air or gas cleaning. A fine wire grid across the air stream is charged negatively at 30 or 20 kV. relative to a second grid, also across the air stream downstream of the first. The first grid sends a stream of ions towards the second; these ions collide with the passing dust particles and charge them, so that they are attracted towards the positive grid and a proportion is held there. By using two precipitators alternatively, one may be cleaned by rapping while the second is collecting dust. This type of cleaner is usually large and expensive, and used for cleaning exhaust gases from process plant.

Inertial Separators

Although the inertia of particles is used in filtering by screening, the term "inertial separation" is usually under-

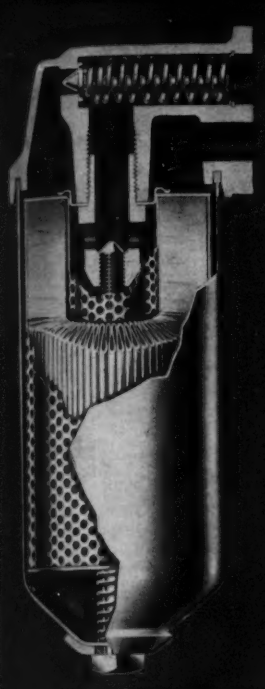


Fig. 7. Full-flow lubricating oil filter, showing pleated paper element and by-pass valve (Automotive Products).

Fig. 8. Oil-driven centrifugal cleaner by Glacier Metals Ltd.

Fig. 9. Tecalemit pleated felt filtering element.

stood to refer to devices where the fluid velocity is altered in direction suddenly, so that the particles tend to carry on in their original path and separate out. The method is commonly used for pre-cleaners in air filters, and indeed the oil bath cleaner is an inertial separator. The incoming air strikes the surface of the oil and reverses direction. This results in a high proportion of the dust being deposited in the oil bath. The remaining particles and entrained oil then enter a wire mesh where a combined filtering and inertial separation process occurs. The entrained oil wets the mesh so that impinging particles are more readily retained.

Illustrations of the various types of filter are shown on these pages.

Installation of Filters

ENGINE LUBRICATING SYSTEMS—The filter is usually placed in the main oil line, between the oil pump and the main gallery. The oil pressure in the bearings then partly depends on the restriction due to the filter. This can be high with cold oil or with a blocked filter, and engine oil filters installed in this way usually have a valve. This valve opens and by-passes the filter element, usually at about 15 p.s.i. drop across the element. The filter may also have in its body a relief valve for the pump, spilling back to the sump. The system is known as the full-flow system (Fig. 6a).

An alternative is to place the filter in a line between the main gallery and the sump, so that a proportion of the oil delivery is filtered and returned to the sump. To limit the quantity bled off, a restrictor is placed downstream of the filter. The system is known as the by-pass system (Fig 6b).

The by-pass system enables the same size filter to have a higher efficiency than the full-flow filter, because its flow rate is lower, but the oil has to circulate a number of times before the probability that all large particles have been removed is high. Present-day practice, substantiated by extensive tests on engine wear in the U.S.A., is towards full-flow filters.

FUEL SYSTEMS—The fuel filter is a full-flow filter, usually employing fine paper, without any by-pass valve. It is also usually larger for the flow rate than a lubricating oil filter. This means that the efficiency is higher, and that the pressure drop is lower, so that it may be used with gravity feed. It is usually placed between the feed pump and the main metering pump in C.I. engine or aircraft engine fuel systems.

HYDRAULIC FILTERS—The hydraulic filter is usually a full-flow filter, generally without by-pass valve. It may be placed before or after the pump. Often the weight resulting from a canister large enough to house the filter element, and withstand the pressure of a high-pressure system, results in the filter being made a low-pressure type at the pump inlet. If this is done, the pressure drop across the filter must not result in cavitation at the pump.

AIR FILTERS—The air filter is invariably placed at the intake to an engine or system. Because a low pressure drop is desirable, resulting in a large filter, the body of the filter is often used as a resonant chamber so that the filter is also an intake silencer. Such silencers are generally tuned low-pass acoustic filters, giving attenuation at frequencies above the resonant frequency, which is designed to be well below engine frequency.

SERVICING—Apart from the self-cleaning types, which are usually coarse filters, all filters need cleaning or renewing at regular intervals. It is generally true that no filter material which is used in depth, i.e., felt, paper, cloth, can be renewed completely by back-washing. This applies particularly to the resin-impregnated paper type of element.

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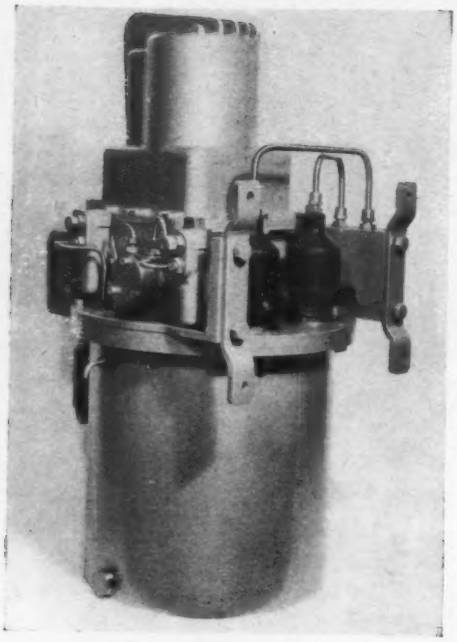
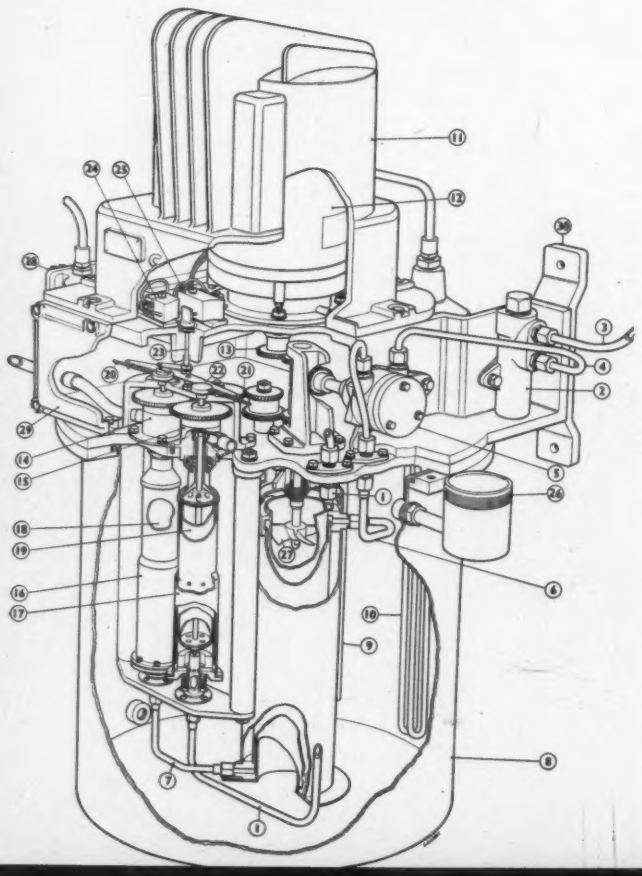
NEW IDEAS IN DESIGN

Outstanding products in current manufacture

Instrument for Automatic Control of Viscosity





THE principal difficulty encountered in controlling viscosity during a continuous process is that a change of as little as 1 deg. C. may result in errors as great as 5 per cent of the final measurement.

By employing two viscometers of the rotating cup type, one of which measures a sample from a pump line, the other providing a reference, in that it continuously measures the viscosity of a laboratory-prepared sample, the Smiths viscosity controller is claimed to provide continuous control of a blending process to within 1 per cent. Both viscometers run in a water bath and are driven at the same speed by an electric motor. The laboratory-tested sample in its viscometer is at the temperature of the bath and the sample from line quickly attains that temperature as it passes through the heat exchanger, which is also immersed in the bath. Output torques from the two viscometers act upon a balance arm. When the viscosities are equal, it follows that the balance arm will be in a state of equilibrium. An adjustment is provided for the fulcrum of the balance arm to compensate for slight differences that may exist between the gaps between the moving and static elements of the two viscometers.

A standard sample, having the viscosity desired of the product, is fed by gravity through a filter (not shown in the diagram). Introduced to the sample viscometer through pipe (1), it passes to the lower bearing spigot and cross passages, and from there to the space around the outside of the rotating drum. Finally, it enters through the peripheral holes drilled around the mid-point and fills the annular space between the rotating drum and the measuring drum.

Oil from the blending line enters the strainer (2), through the pipe connection (3), and thence flows through the pipe (4) to a pump. The strainer has a very small capacity: a large capacity would unduly delay the signal that indicates change of viscosity. The pump (5) is introduced mainly to isolate the apparatus from line pressure. Oil passes through the pump, enters the heat exchanger via the pipe connection (6), then flows through the connection (7) into the in-line viscometer. The heat exchanger is provided to ensure that oil from the line is raised to the same temperature as that of the standard sample in the shortest period possible—approximately 5 sec.

The heat exchanger consists basically of two concentric metal sleeves. Oil from line is forced through the annular space between them, whilst water is circulated by means of the impeller (27), through the inner sleeve and the water jacket surrounding the outer sleeve.

Temperature of the water bath (8) is maintained by means of a thermostat (9) governing a heating element (10). The exact temperature is not important, but it is set to a figure that ensures that the viscosity of the line sample, and hence the torque produced at the viscometers, is not unduly high for the type of mechanism. Water is used for the bath, and in conditions where extremely low temperatures may be expected, an anti-freeze solution is recommended. The water bath is topped-up through the filling cap (26) to a line engraved below the optic.

The electrical side of the controller is of flameproof construction and the apparatus may be used in hazardous atmospheres. The top cover (11) is cut away in the diagram to reveal the driving motor (12). This motor drives the spur wheel (13), which in turn drives the pump (5) and rotating

outer sleeves of the viscometer (14 and 15).

The oil then passes to the viscometers, where rotation of the outer cylinders (16 and 17) causes a viscous drag on the inner, or measuring cylinders (18 and 19). This torque is applied to the arms (20 and 21), which act upon the balance arm (22). Excessive stresses are obviated by the use of lengthy arms, so that frictional forces on the central pivot of the balance arm are minimal. Motion of the balance arm is transmitted through the shaft (23) to operate the micro switches (24 and 25).

An important constructional point is the method of sealing the shafts from the sensitive cylinders to the balancing mechanism. In this application, it would be quite valueless to provide conventional seals because with some low-viscosity products an out-of-balance torque of a mere 2 gm. would represent a viscosity change of 1 per cent. A novel method of construction (see diagram) causes the oil to be discharged from the viscometers without creeping up the shafts.

The viscosity controller depicted in the diagram is a simple on-off electrical type, and the micro switches in this application would be used to control a relay box, and hence a motorised control valve in the blending unit. For pneumatic control, the micro switches would be eliminated and replaced by a drive taken from the balance unit, by bevel wheels, to a pneumatic controller.

The terminal box (28) is of flameproof construction and is arranged for Pyrotenax connection. Access to the mechanical balancing unit may be gained by removal of the cover (29).

A Recording Flowmeter of High Accuracy

THE Pottermeter, now manufactured by de Havilland Propellers Ltd., enables the flow rate of a range of liquids of widely varying viscosities to be measured with extreme accuracy. Accuracies of $\pm\frac{1}{16}$ of 1 per cent are said to be not uncommon. The complete Pottermeter system consists of a sensing element, which uses the kinetic energy of the measured fluid, and a suitable indicating or recording unit, which can be placed any distance from the sensing unit.

The cutaway view shows the operating principle of the sensing unit. A bladed axial rotor is positioned at the centre of the liquid flow, which is prevented from forming vortices by the presence of three guide tubes both in front of and behind the rotor. The rotor body has been so designed that, when rotating, it advances slightly towards the inlet side and is prevented from bearing against either end by its shape. Thrust friction is thus eliminated and the rotor spins freely on plain guides, without slippage, at a rate governed by, and directly proportional to, the velocity of the flow through the unit. Mounted within the body of the rotor is a small permanent magnet which, as the rotor spins, sets up an alternating current in a coil of wire held within its field. The total number of pulses generated by the sensing element is directly proportional to the total quantity of liquid passing through it. The frequency of the alternating current produced is directly proportional to the rate of flow of the liquid through the sensing element.

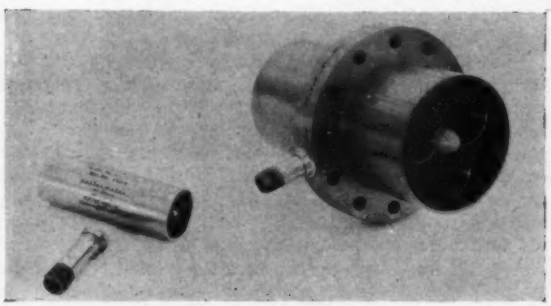
When used in conjunction with an electronic totaliser, the Pottermeter measures flow with great precision. When it is desired to measure rate of flow, the electrical output of the sensing element is applied to an electronic frequency converter, which produces a d.c. signal proportional to frequency. This signal can be measured as a rate of flow by either a milliammeter, an electronic potentiometer or a high-speed recorder. The manufacturers point out that systems of rate measuring depend on the degree of precision of the instrument used to read the output of the frequency converter, but systems with an overall accuracy of $\pm\frac{1}{4}$ per cent or better for instantaneous flow measurement are available.

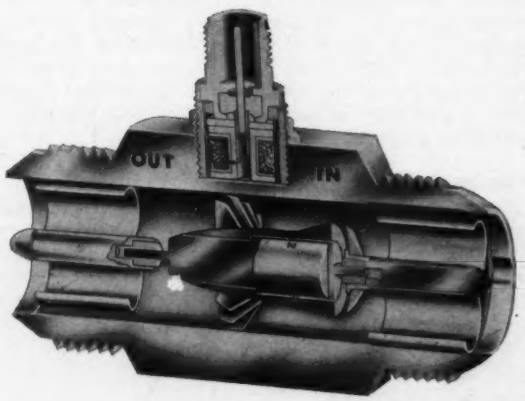
Notable features of the Pottermeter are the extreme sensitivity to flow rate changes and insensitivity to pressure changes. Tests are claimed by the manufacturers to show that the rotor responds to a flow rate change in the time required for it to make one revolution, the average response time being about 10 milliseconds. It is stated that, as long as a minimum of 5 p.s.i.g. is maintained at the discharge side of the meter, the sensing element is not affected by pressure changes.

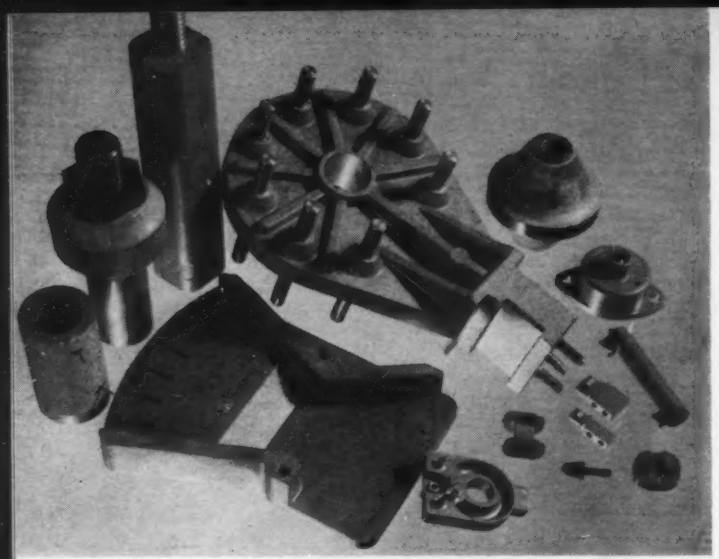
Accuracy of the instrument is said to be unaffected by variations in the density of the measured fluid. When it is desired to record or measure the rate of flow in weight units, the electronic frequency converter used in the measuring system can be furnished with a density adjustment control to compensate for different specific gravities.

Although viscous fluids tend to increase the downstream drag on the sensing element rotor, thus shortening the range of linear operation of the sensing element, it is claimed that the units will accurately reproduce readings despite decreased linearity at higher viscosities. Suspended particles can be tolerated and cause no loss of accuracy, provided that the particles are small enough to pass freely between the rotor blades without excessive erosion.

It can be supplied in sizes suitable for the measurement of flows from 0·1 to 4,500 Imp. gal./min. Larger sizes are made to special order.







GLASS-BONDED MICA INSULATION

by S. POSTLE, A.M.I.E.E. *

A review of the production methods of inorganic insulation materials and their effect on their properties and industrial applications

GLASS-BONDED mica can be compression- and injection-moulded to almost any shape for many purposes. The compression-moulded material is available in the form of sheets, rods and pieces cut to order. There is no great difficulty in machining with ordinary machining tools, provided the technique is thoroughly understood. The injection-moulded material is made from injection or transfer moulds in a very similar manner to normal plastics mouldings, except that much higher pressures and temperatures are employed. The mechanical advantage, compared with most plastics, is that there is no shrinkage or warping after moulding and therefore very close tolerances can be maintained, particularly as the coefficient of expansion is very similar to that of most usual steels.

Another important advantage is that inserts can be moulded in position, unlike the ceramics where they have to be inserted afterwards by another process.

Electrically, glass-bonded mica is interesting in that the superior electrical qualities of the mica, such as low power factor, high surface and volume resistivity and good dielectric strength, can be made to combine with low-temperature glasses where these properties are relatively poor. Over a frequency range of 10^2 to 10^8 c/s, the power factor varies for both types of glass-bonded mica, compression- and injection-moulded. It should be noted that the permittivity remains more or less constant up to 10^6 c/s.

Another important feature of glass-bonded mica, so far as the power frequency use in all types of switches and switchgear is concerned, is that it is non-tracking and arc resistant, since, being inorganic, there are no carbon-forming chemicals in the composition; thermally, the working limit is 450 deg. C. It is also noteworthy that under conditions of vacuum there is little or no release of gas. By suitably combining the mica and glass in different proportions, a particular set of required electrical, thermal or mechanical properties can be emphasised.

Manufacture

COMPRESSION-MOULDED SHEETS AND RODS—The sheet material is preformed into slabs made from the main ingredients, finely mixed muscovite mica and a boro-silicate glass or enamel. The limitation of the temperature of about 650 deg. C. of the glass is imposed because of the disintegration of muscovite mica at much above this temperature. The mica to glass ratio is in the order of 1½:1.

The preformed sheet is pressed hydraulically at about 1½ t.s.i., after which it is fired in a furnace at about 650 deg. C. This causes the glass element of the composition to complete its reaction by vitrification so that it combines with the mica. The now semi-molten sheet is taken from the furnace and pressed in a hot press at about 1 t.s.i. until it sets. It is found during the two pressing operations that the mica flakes tend to orient themselves so that their larger surfaces lie perpendicular to the direction of pressure and parallel to the sheet faces. It is interesting to compare this action with the fact that mica lies in strata in the ground.

After the sheet is cool it is surface-ground to remove a deleterious surface skin of relatively poor electrical quality.

TRANSFER OR INJECTION MOULDINGS—Glass-bonded mica mouldings are relatively new compared with the sheet material, but their use is rapidly overhauling the latter in scope and application. The main ingredients are phlogopite mica because of its greater heat-resisting qualities than muscovite. The other main ingredient is a lead borate glass. Small pellets are preformed from a combination of the mica and glass and heated to fusion point in rotary furnaces at 650 deg. C. Compared with sheet material, however, the mica to glass ratio is lower, so that there is more glass than mica to facilitate flow under pressure and high temperatures into the mould cavities.

The required number of pellets are then transferred quickly to the mould hoppers and the press operated so that the ram forces the molten pellets into the mould cavities through suitably constructed feeds. The mould temperature is maintained at as near 300 deg. C. as possible. The moulding then sets because the mould temperature is lower than the setting point of the glass. Every endeavour is made to impart as good a surface as possible to the mould during manufacture so that the ultimate moulding has, to all appearances, a glass-like surface finish.

Inserts are easily incorporated into the moulding during the moulding process by suitably designed mould cores and pins. There is no distortion, warping or cold flow during or after cooling, and contraction approximates to that of the usual steels. As a result of this small contraction, very close tolerances can be maintained, particularly as the coefficient of linear expansion approaches that of steel.

Applications

COMPRESSION-MOULDED SHEETS AND RODS—The hardness, tensile and compressive strength, together with good machinability, make glass-bonded mica sheets compare

* *Mycalex & T.I.M. Ltd.*

favourably with any other plastics or ceramic insulation available to engineers today.

The main uses lie in high-frequency applications such as coil formers, struts, panels, commutator segments, contact housings, end plates, oil-filled condenser and transformer covers, and many more uses where low loss factor is important.

Due to glass-bonded mica being non-tracking and arc-resistant, its appeal to switchgear designers for use as arc shields and chutes in power frequency application is of paramount importance, because the material will not carbonise when arcs form under rupture conditions.

An unusual but important application is met with in 1,500-watt ultrasonic generators designed and built for the continuous production of synthetic blood plasma. Machined glass-bonded mica sheets were found to be most suitable for withstanding the powerful chemical and electro-mechanical stresses during production.

High-voltage condensers of 15 or 20 kV peak working in units up to 5,000 mmF. capacity made from glass-bonded mica interleaved with electrodes is another example of its utility, particularly as the space saving in, for instance, H.F. induction heating equipment is considerable. Power factors of the order of 0·00075 are achieved with a dielectric strength of 500 volts per 0·001 in. Again, low-temperature heating panels, in which nickel-chrome wires are sandwiched in the sheet, is another application; outputs of anything up to 2 watts/sq. in. of surface area or 1 watt/sq. in. of each of the two faces is usual.

Apart from domestic uses, such heating panels are installed as desiccators in transmitting, receiving and radio equipments generally, especially where equipments are left idle for long periods of time such as, for example, on board Service ships. Low-temperature furnaces or ovens made from several sheets is a further example among many more which serve to show their many uses.

INJECTION-MOULDED GLASS-BONDED MICA—Electrically, glass-bonded mica mouldings are non-absorptive, non-tracking and have a dielectric strength of the order of 500 volts per 0·001 in. with a power factor of under 0·002 and a permittivity of between 9 and 11 according to constitution. Thermally, the working limit is nearly 400 deg. C. Among their varied uses, many of which are similar to those mentioned under the previous heading of sheet material, there is the unique property of their being X-ray absorptive according to the amount of lead glass used in the composition. To quote an example of this, cathode caps and cable sockets are now being manufactured with an absorptive equivalent of 25 per cent for an X-ray beam of 100 kV. peak. In other words, the absorptive power of, say, 4 mm. of glass-bonded mica is equal to the absorptive power of 1 mm. of pure lead hitherto used. Another use is the development of insulators for use as brush holders in electric traction motors and high-tension insulators for such equipment as power station electrostatic flue gas precipitators.

*TABLE 1. Test figures obtained with glass-bonded mica materials**

	MLD Mycalex Mouldings	LDS Mycalex Sheet	Micatherm Sheet	Mycalon Mouldings
Electrical Properties				
Electric strength	500 volts/0·001 in. average	> 500 volts/0·001 in.	> 400 volts/0·001 in.	(B.S. 1 min. test) 380 volts/0·001 in.
Surface flashover	19 kV. between electrodes 1 in. apart	20 kV. between electrodes 1 in. apart.	20 kV. between electrodes 1 in. apart	—
Volume resistivity, ohm/cm³	> 10^{14}	> 10^{14}	> 10^{14}	10^{14}
Surface resistivity, ohm/cm.²	5 × 10^{13}	5 × 10^{9}	5 × 10^{9}	10^{14}†
Permittivity, at 1 Mc/s	10·5 average	7 average	—	9·7
Power factor	0·002 average at 1 Mc/s	1 kc/s 0·007–0·009 1 Mc/s 0·002 average	—	0·0013
Edgewise breakdown	—	Test pieces did not breakdown at 40 kV., the maximum voltage available.	—	—
Mechanical Properties				
Specific gravity	4·4 average	2·68 average	2·5 average	4·0
Tensile strength, p.s.i.	2,000 average	6,000 average	6,000 average	3,000
Compressive strength, p.s.i.	10,000 average	13,500 average	13,500 average	30,000
Shear strength, p.s.i.	8,400 average	10,000 average	10,000 average	—
Impact value	0·5–0·9	0·5–0·8 (Schlerescope 40)	—	0·17 (Izod 1 ft. lb. strike)
Flexural or cross-breaking strength, p.s.i.	4,000	13,500 average	13,500 average	4,000
Hardness (Brinell)	—	37–47	—	—
Thermal Properties				
Softening or plastic yield temp., °C.	400	450	500	400
Coefficient of thermal expansion	—	—	—	10 × 10^{-6}/°C. (20–300°C).
Resistance to tracking (surface carbonisation)	Non-tracking	Non-tracking	Non-tracking	Non-tracking
Thermal Conductivity, B.t.u./sq. ft./hr./°F./in.	6·0	5·2	5·2	—
Resistance to arcing, sec.	150	150	300	—
Maximum thermal shock temp., °C.	375	300	350	375

* Tests by National Physical Laboratory, National Engineering Laboratory and other bodies.

† This value is also obtained after 2 hr. recovery from six R.C.S. 11 accelerated humidity cycles.

HYDRAULIC STEPLESS TRANSMISSIONS

This article reviews the various forms of fluid-operated stepless transmission units that are available to the designer, and gives details of sizes and other important data

by W. E. LOCKE *

HYDRAULIC variable-speed units are generally more flexible, but initially more expensive than their mechanical counterparts, but this may be offset by reduced maintenance and replacement costs. They are resilient to shock loadings, frequent changes of speed, or reversals of shaft rotation and to stalling when it is expected. The units are usually of the group whose characteristics are a combination of variable output torque and speed, the input being normally a constant speed with variable torque up to a maximum.

The overall efficiencies of these hydraulic units are high, and the ratios obtainable are in general between zero and 1:1. By virtue of the fluid used, they are self-lubricating, and any cooling needed to dissipate the heat generated is inherent in the design of the unit. Some types incorporate a mechanical or hydraulic lock at the top ratio of 1:1, so that the drive is direct and the slip negligible.

The hydraulic drive is basically a combination of pump and motor built into one compact unit, although for certain applications two individual units interconnected by pipelines may be used. Both pumps and motors are either constant displacement or variable displacement units. In constant displacement types the volume of fluid displaced during one revolution is always constant, except for a small "slip" loss varying with the pressure; thus the output of the pump is directly proportional to the speed. In the case of the constant displacement motor, the speed is directly proportional to the inflow. Typical examples of the positive displacement pumps used in hydraulic machinery are the vane, gear, radial and axial piston types.

For increased flexibility required in many applications it may be advantageous to use a separate pump and motor which enables the designer to consider each unit individually and match them according to the overall design problem. With this system, additional losses will be incurred from the pipe system and the various valves incorporated.

One of the more recent applications has been in hydrostatic transmission for tractors.

In the variable displacement type of pump the flow delivery can be varied, while a constant pressure is maintained. These are usually of the piston variety, but there are others in use. Four arrangements of hydraulic drive are possible to give varying characteristics:

1. Fixed displacement pump and motor used with a throttle valve.
2. Constant delivery pump used with a variable displacement motor.
3. Variable delivery pump used with a fixed displacement motor.
4. Variable delivery pump used with a variable displacement motor.

With a fixed displacement pump and motor, speed variation is possible at the motor end by by-passing some of the fluid to the suction side of the pump, by means of a restricting valve which maintains the pressure in the circuit (see Fig. 1). For large speed variations this arrangement is uneconomic, since the fluid horsepower unabsorbed by the motor is converted into heat, which raises the temperature of the fluid in the circuit, and is thus wasted, the energy input to the pump remaining substantially constant. In certain applications where the output speed variation is small, this type may, however, be the correct choice, since its initial cost is appreciably lower than units with variable delivery mechanisms. Fixed displacement pumps and motors are usually employed as separate units with an external circuit.

A combination of fixed displacement pump and variable displacement motor provides a constant horsepower and variable torque output, while with a variable displacement pump and a fixed displacement motor the output torque

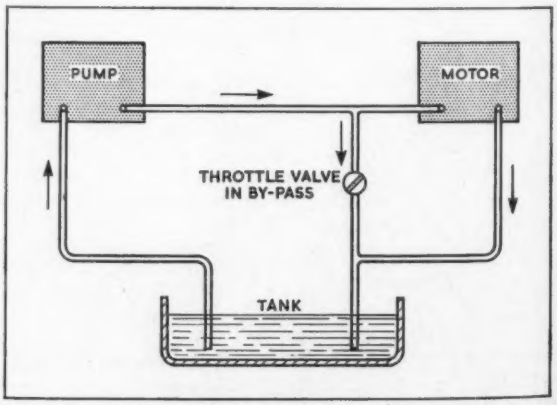


Fig. 1. Diagram of a simple hydraulic circuit with fluid supply, pump, motor and by-pass throttle.

* *Flight Refuelling Ltd.*

remains constant, the horsepower being variable; with both pump and motor of variable displacement, output torque and horsepower can both be varied. In the last three combinations the output variations are controlled by the fluid-flow variations in the circuit, these in turn being controlled by the displacement mechanisms in the units.

In general, variable speed units employ piston-type pumps and motors, since these usually operate at the best efficiencies and highest pressures. Vane types are more suited to the lower pressure ranges—around 1,000 p.s.i. and under—and are usually cheaper to manufacture than the piston units, which involve high precision manufacturing techniques and contain many parts.

The following questions will show the type of information required to enable proposals to be submitted, but these are necessarily general and the answers should be supplemented, wherever possible, by such additional particulars as may be peculiar to each case. It is also helpful wherever possible to supply the manufacturer with a drawing of the proposed drive.

1. For what purpose is the machine required?
2. How is it proposed to drive the gear?
3. What is the normal working speed range required?
4. Is gear required to be fully reversible, reversible at slow speed only, or irreversible?
5. Are exceptional speeds required such as higher than normal or lower for "inching", etc., and for what period?
6. What h.p. is required to be transmitted at the various speeds?
7. If possible, state the maximum torque.
8. Will operation be continuous or intermittent? If the latter, state approximate times of running and standing periods.
9. Are extremes in temperature or other abnormal physical conditions likely to be met with, and is cooling water available if required?
10. What type of controls will meet the requirements?

MAIN AVAILABLE UNITS

Aero Maintenance Equipment Ltd.

The French-made range of HEF Soma hydraulic pumps and motors is based on a new patented idea of coupled profiles of hypocycloidal form. Consisting of two rotors, the pinion or inner rotor has one tooth less than the ring gear or outer rotor. The operation is such that each tooth of the pinion is in continuous sliding contact with a tooth on the ring gear, providing fluid-tight engagement, valving being effected by crescent-shaped slots extending axially.

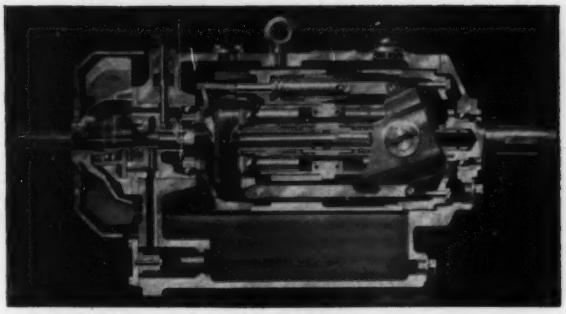
The HEF pumps and motors are said to combine the simplicity and high flow with compactness of a gear pump with the robustness and possibility of high-pressure operation (in excess of 2,000 p.s.i.) of the piston pump. High volumetric efficiencies are possible with exceptional silence in operation.

This series of pumps provide for flow rates from 2-95 gal./min. while the motors cater for output horsepower of 2-140 h.p.

B.H.R.A. Laboratory

A recent and very promising development in the hydrostatic differentially-coupled transmission field is a low-loss valve system. The general arrangement of this transmission, which was designed for use in an average motor car, comprises two axial piston pumps mounted end-to-end in a common housing which rotates with the output shaft. The delivery of one pump is variable and the reduction of output speed is produced differentially. Both pump and motor are swashplate-operated, and the variable delivery is obtained by altering the angle of the output swashplate.

A loss analysis of an earlier machine of this type showed that the greatest single loss was due to the plate-type valves,



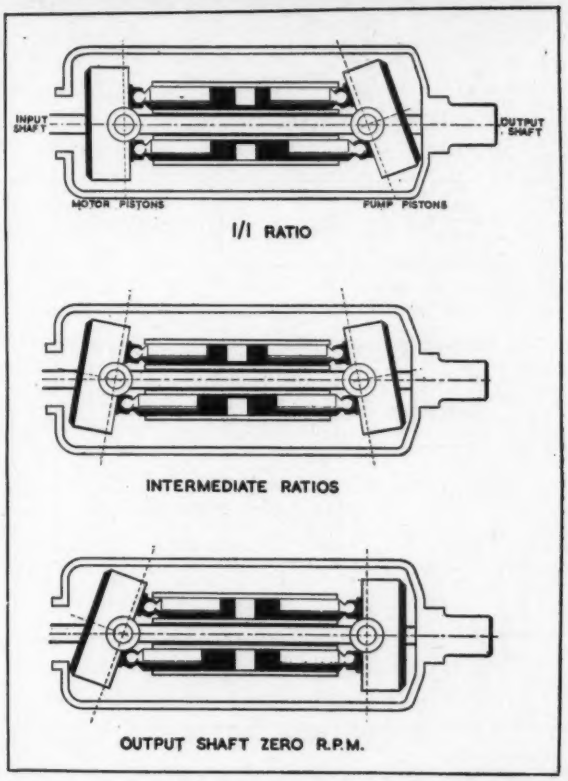


Fig. 2 .The top illustration is a section through the David Brown Varicon. The diagrams below show position of swashplates for two extreme ratios and an intermediate ratio.

where leakage, hydraulic losses and mechanical friction were high. However, a new valve system devised at the British Hydromechanics Research Association's laboratory eliminates plate-type valves and uses a modified part of the pistons as valves. Since a piston cannot easily operate as its own valve, the system is arranged in a manner whereby each valve controls the flow to a piston displaced from it by 90 deg. Although this method of valving demands a rather complicated oil-way arrangement, it does not require more space than other systems.

David Brown Industries Ltd.

The Varicon stepless speed reducer will give an infinite number of speeds between zero and 1:1; normal requirements are met by a reduction of $6\frac{1}{2}$:1.

The unit incorporates hydraulic pump and motor systems, both being of the positive displacement type. Axial pistons are fitted, under swashplate control (see Fig. 2).

With the pump swashplate at maximum deflection and the motor swashplate at zero deflection, a hydraulic lock

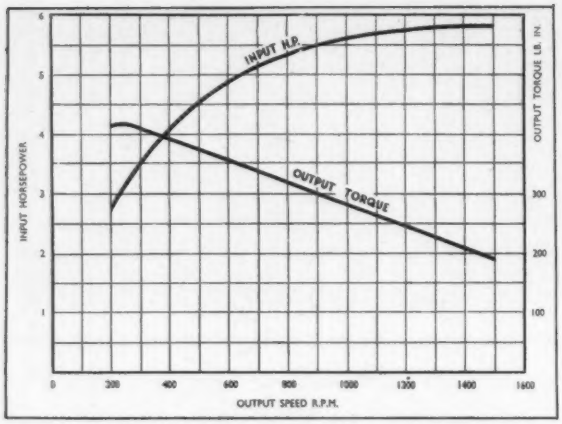


Fig. 3. Performance curves for 5-h.p. Varicon unit.

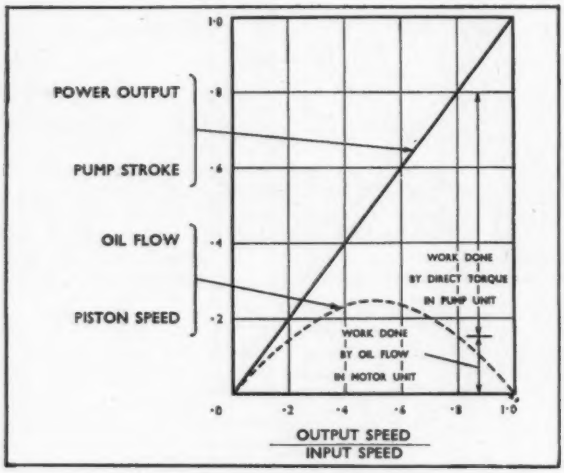

POWER OUTPUT
PUMP STROKE
OIL FLOW
PISTON SPEED
WORK DONE BY DIRECT TORQUE IN PUMP UNIT
WORK DONE BY OIL FLOW IN MOTOR UNIT
OUTPUT SPEED / INPUT SPEED

Fig. 4. Power output of a Carter variable gear.

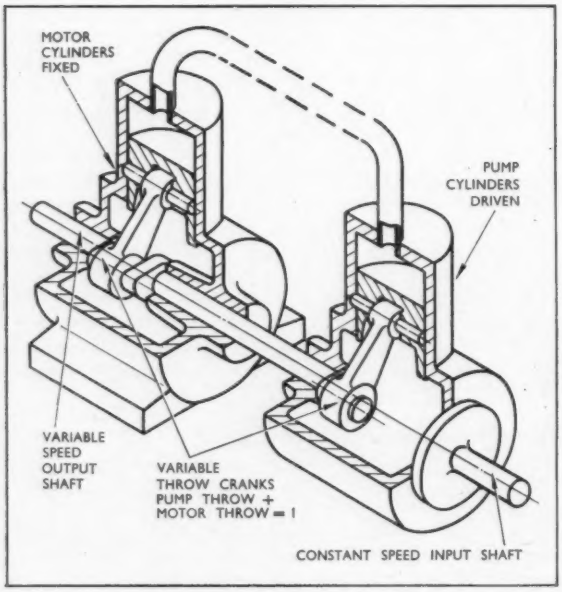

MOTOR CYLINDERS FIXED
PUMP CYLINDERS DRIVEN
VARIABLE SPEED OUTPUT SHAFT
VARIABLE THROW CRANKS PUMP THROW + MOTOR THROW = 1
CONSTANT SPEED INPUT SHAFT

Fig. 5. Operation of Carter type "A" gear.

exists between pump and motor, since the motor pistons cannot operate, and a 1:1 wholly mechanical drive is established between input and output shafts. For zero r.p.m. at the output shaft the arrangement is reversed, in that the motor swashplate is at maximum deflection, and the pump swashplate is set normal to the shaft. Intermediate ratios are obtained by simultaneous inclination of both swashplates. The unit is fan-cooled and can be hand- or remote-controlled. Optional equipment includes a revolution counter and a dustproof ventilator.

Performance curves are shown in Fig. 3.

Table 1

	I/P		O/P		
	Max. speed r.p.m.	h.p.	Speed r.p.m.	Max. starting torque lb. in.	Max. output torque lb. in.
Varicon	2,000	5	I/P–0–I/P	500	450
	1,800	10	,,	975	875
	1,800	15	,,	1,500	1,360

Carter Gears Ltd.

TYPE "A" GEAR—This is a special form of positive displacement variable-speed unit, using mineral oil as the power transmitting medium. In combination with a standard a.c. cage-type electric motor of any make or form of enclosure, it forms a compact unit capable of picking up loads from standstill, and having an overall continuous running speed range under load of approximately 27:1 ratio.

In conventional hydraulic transmission gears all the power is transmitted by movement of a volume of oil; this is directly proportional to the output speed required, and is delivered by a variable displacement pump driven at constant input speed to a constant capacity hydraulic motor which drives the variable-speed output shaft. If, neglecting efficiency, the working pressure remains constant throughout the speed range, the power transmitted will be directly proportional to the flow and thus to the output speed, and the gear will transmit a constant output torque.

The Carter "A" type gear is designed in such a way that at the maximum output speed there is no oil flow or relative movement of working parts other than bearings, and all power is transmitted by direct torque from the input to the output shafts. The maximum oil flow and piston speed, which occur at 2:1 speed ratio, are only one-quarter of the maximum found in gears of the conventional type designed for the same working pressure, speed range and power output; at all output speeds some proportion of the power is transmitted by direct torque (see Fig. 4).

The Carter gear design can best be understood by considering a simple piston-type oil pump. If during the delivery stroke the outflow is cut off, the resultant oil pressure

Table 2

Type	I/P		O/P		
	Speed r.p.m.	H.P.	Speed r.p.m.	H.P. at max. speed	Torque at all speeds, lb. in.
"F" type					
F.10	1,420	¾	1,420–0–1,420	0·625	28
F.12	1,420	1½	1,420–0–1,420	1·25	56
F.14	960	3½	960–0–960	3·0	197
"A" type			Max. O/P speed		
1A	1,410	2	1,350	1·65	77
2A	1,420	3	1,370	3·0	138
3A	1,430	5	1,385	5·0	228
4A	1,440	7½	1,400	7·5	337
5A	960	12½	930	12·5	846
6A	965	20	940	20·0	1,340
AL.50	725	40	700	40·0	3,600

Table 3. Relative movements of components of Carter "A" type gear

(a) Output shaft speed	(b) Input cylinder block speed	(c) Pump unit speed (b − a)	(d) Pump unit stroke	(e) Oil delivered by pump (c × d)	(f) Motor cylinder block speed	(g) Motor unit speed (a − f)	(h) Motor unit stroke (1 − d)	(i) Oil received by motor (g × h)
1	1	0	1	0	0	1	0	0
¾	1	¼	¾	1/16	0	¾	¼	1/16
½	1	½	½	¼	0	½	½	¼
¼	1	¾	¼	1/16	0	¼	¾	1/16
0	1	1	0	0	0	0	1	0

in the cylinder will produce a torque on the cylinder block equal to that in the crank, and tending to rotate it in the same direction and at the same speed. Similarly, if a moment is applied to the block in the opposite direction, the same torque and direction of rotation will be given to the crank; this is the action at 1:1 ratio.

If, on the other hand, the oil is allowed to pass out of the cylinder under pressure, at some rate less than the normal capacity of the pump when the block is stationary, then the cylinder block and crank will revolve at different speeds depending on the flow, but each will exert a torque equal to that on the other. The oil passing under pressure from the cylinder is fed to a motor to produce a useful turning moment, and by connecting the cranks of both pump and motor units the turning moments can be combined. This is the action of the gear at ratios other than 1:1.

The main hydraulic system is fitted with non-return valves, which make it suitable for either direction of rotation and for use in reversing the input drive without modification.

The output speed of these units is governed by a control mechanism which can be operated manually, electrically or pneumatically.

TYPE "F" GEAR—This is a low-power infinitely variable speed gear capable of picking up a load from zero speed, and giving a smooth, stepless range of output speeds up to input speed, in both directions of rotation from a unidirectional constant input. The direction of this input is normally clockwise, though an anti-clockwise assembly may be easily arranged.

Chamberlain Industries Ltd.

This company produces the Staffa range of radial hydraulic motors of monobloc construction with detachable cylinder heads. The design allows for the crankshaft to rotate in either direction.

Table 4

Motor type	Pressure max. p.s.i.	O/P torque lb. ft.	O/P speed r.p.m.
No. 4: 5-cyl.	2,000	4,500	100
7-cyl.	2,000 nom.	6,600	75

Churchill-Sturm Ltd.

This unit is of the usual variable displacement pump and motor configuration, but employs vanes instead of pistons as the oil-displacing members. The displacement variations in both pump and motor are achieved by moving the housings transversely across the axis of the unit.

With a constant input speed and the output shaft at a standstill, the position of the pump housing is concentric with the rotor holding the vanes, so that there is no displacement of oil and the motor remains at rest. When, however, the pump control lever moves the housing into an eccentric position, oil is delivered to the motor, which is at its maximum eccentricity, and it starts to rotate. The output shaft speed thus varies steplessly with alterations in the pump delivery.

When the pump housing is at maximum eccentricity, the motor speed has risen to about one-fifth of its maximum,

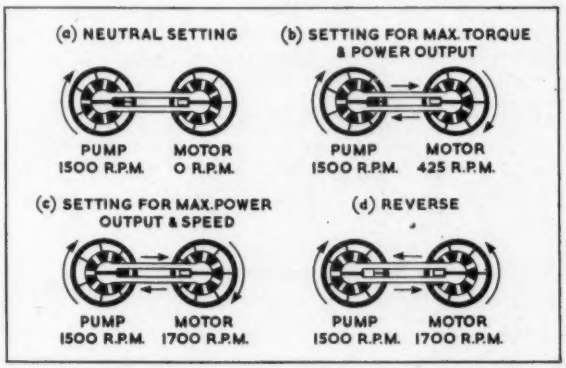


Fig. 6. Principle of the Churchill-Sturm hydraulic drive unit.

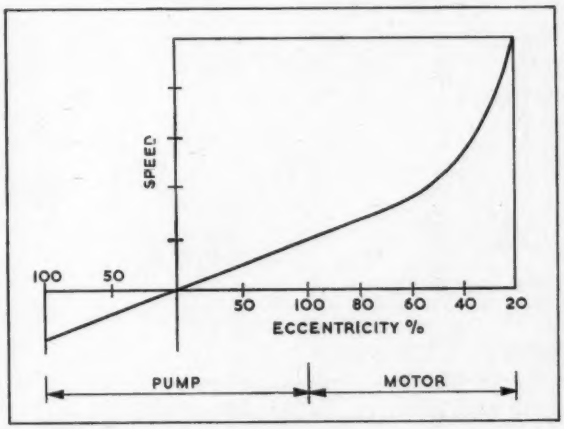


Fig. 7. Relation between eccentric housings and speed of Churchill-Sturm drive.

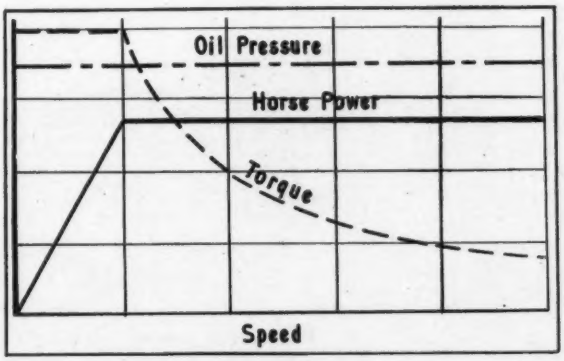


Fig. 8. Power characteristics of a Churchill-Sturm unit.

and the motor is developing its full horsepower. For a constant pressure, the torque during this period, which depends on the motor housing eccentricity, remains also constant.

From this point onward, with the pump at maximum displacement, the horsepower stays constant, and the speed of the output shaft can be increased by reducing the eccentricity of the motor housing, while the torque falls off proportionately. Maximum speed is reached when the motor eccentricity is down to about 20 per cent.

To reverse the direction of rotation of the output shaft, it is only necessary to change the direction of the pump eccentricity, which reverses the flow through the motor.

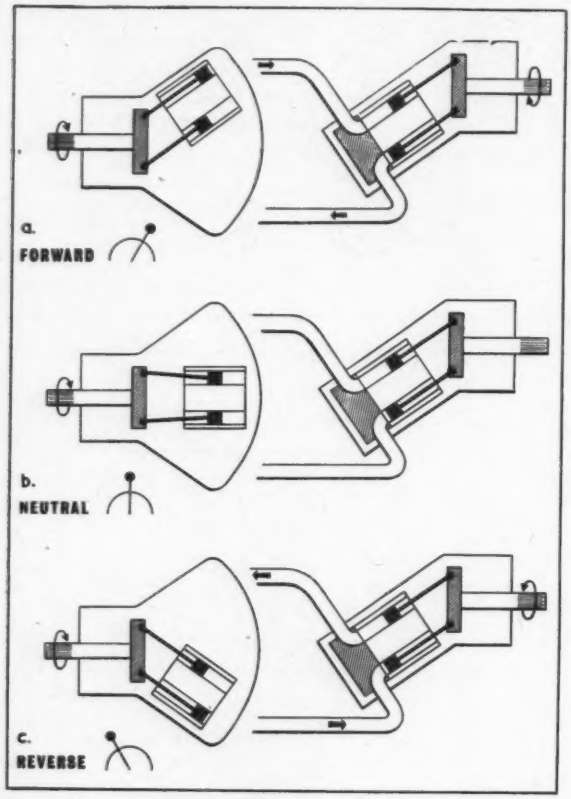


Fig. 9. Operating sequence of a Dowty Dowmatic unit.

Table 5

Type	I/P speed r.p.m.	O/P speed r.p.m.	Max. h.p.	Max. torque lb. ft.
CA.11	1,500	2,000–0–2,000	1·25	12
C.13	1,500	1,800–0–1,800	2·5	30
C.24	1,500	1,700–0–1,700	3·5	42
C.35	1,500	1,600–0–1,600	5·0	70
C.46	1,500	1,500–0–1,500	7·0	110
C.57	1,500	1,320–0–1,320	10	180
C.68	1,500	1,180–0–1,180	14	310
C.89	1,000	950–0–950	20	545
CL.15	1,000	750–0–750	32	1,160

Fig. 7 shows the relationship between the eccentricities of the pump and motor housings and the speed of the output shaft, while Fig. 8 shows the pressure, torque and horsepower at full load throughout the speed range. The efficiency varies at half load and from 75-80 per cent at full load.

The normal speed range of this unit is from 0-2,000 r.p.m. for the smallest model of 1¼ h.p., and 0-750 r.p.m. for the largest model of 32 h.p. If a lower speed range is required, the unit can be fitted with a built-in reduction gear.

Cooling is important with the Churchill-Sturm drive and, while a built-in fan is incorporated in the unit, special cooling arrangements may be required where ambient temperatures are excessive. Pump and motor eccentrics can be controlled either from one lever or separately by various means.

Deri (Engineers) Ltd.

The Deri Sine pump is of unusual design, giving a pulsation-free delivery, with an internal hydraulic and dynamic balance of forces, thereby eliminating bearing loads and vibration, and ensuring quiet running and high mechanical efficiency. Valveless porting gives excellent suction and self-priming characteristics.

Although a positive displacement pump of high volumetric efficiency, it has no pistons but uses two double-cam rotors separated by a stationary dividing plate and keyed to the driving shaft. The two rotors, set at right angles to one another, revolve inside concentric stator chambers, each of which is divided into two pumping chambers by means of brushes located in radial slots in the stators. These brushes are initially held in contact with the rotors by a spring-loaded rocker, pivoted in the dividing plate, and thereafter by hydraulic pressure, only a small differential area between the top and bottom faces being effective. There are thus two equi-spaced pumping chambers swept by each rotor, the sum of the deliveries from both pairs being always constant.

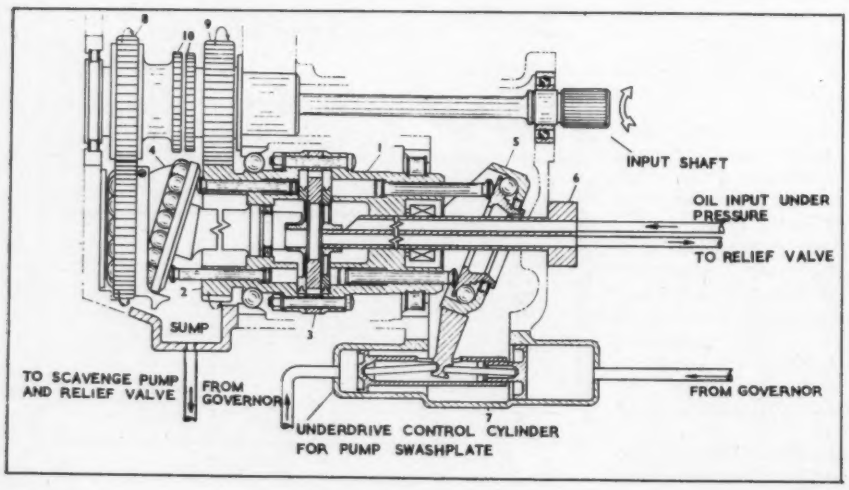


Fig. 10. Arrangement of English Electric unit.

1. *Pump cylinder block assembly.*
2. *Motor cylinder block assembly.*
3. *Port plate.*
4. *Motor swashplate drive shaft assembly.*
5. *Pump swashplate assembly.*
6. *Manifold assembly*
7. *Swashplate control assembly.*
8. *Output gear and clutch assembly.*
9. *Input gear assembly.*
10. *Pump drive for pressurising input oil*

Table 6

PUMP UNITS	Delivery pressure p.s.i., max.	Flow gal./min.
S/3–¼	2,000	0·3–0·6
S/3–1B	2,000	1·2
S/5–½	2,000	2–3·25
S/5–1	2,000	4–6·5
S/5–1½	2,000	8
S/6–1	2,500	4–10
S/6–1½	2,500	8–12
S/6–1½	2,000	15
S/6–2	2,000	20
S/8–1	2,000	10–24
S/8–2	2,000	20–48
S/8–2½	2,000	60
MOTOR UNITS	**O/P speed range r.p.m.**	**O/P torque lb. in., max.**
S/5–½/.2	100–3,000	400
S/5–1/.2	80–2,500	800
S/5–1½/.2	60–2,000	1,200
S/5–2/.2	50–1,500	1,600
S/8–1/K	100–3,000	1,300
S/8–1/.34	80–2,000	2,250
S/8–1½/.34	60–1,500	3,375
S/8–2/.34	50–1,500	4,500
S/8–3/.34	40–1,000	6,750
HEX/S/S–12/6	1–200	36,000

Input speed for all pump units: 1,450 r.p.m. Input pressure for all motor units 2,000 p.s.i. max., with exception of HEX/S/S–12/6, for which it is 1,500 p.s.i.

These pumps cover from fractional outputs to 96 gal./min. and are supplied in two pressure ranges, namely 1,000 and 2,000 p.s.i. They will handle all types of oil from kerosene to heavy fuel oil.

As well as fulfilling all normal hydraulic applications, these pumps will handle the high pressures and deliveries demanded by the pressure jets of oil burners; for domestic burners a special model is available incorporating a combined pressure regulating and cut-off valve if required. The pumps are particularly free from noise and vibration.

The Deri Sine motor is basically similar in design to the pump and by means of a control valve will rotate in either direction with output torques up to 4,000 lb./in.

Dowty Hydraulic Units Ltd.

Several years ago this company began development of the Dowmatic drive specifically for vehicle applications.

Table 7

PUMP UNITS	I/P speed r.p.m.	O/P pressure p.s.i. at 1,500 r.p.m.	O/P flow gal./min.
GP0	3,000 max. 500 min.	1,500	0·5
GP1/10	3,000 max. 500 min.	1,750	1·0
GP1/15	,,	,,	1·5
GP1/20	,,	,,	2·0
GP1/25	,,	,,	2·5
GP2/25	,,	2,000	2·5
GP2/45	,,	2,000	4·5
GP2/65	,,	1,750	6·5
GP2/85	,,	1,750	8·5
GP3/115	2,000 max. 500 max.	1,750	11·5
GP3/170	,,	1,500	17
GP3/250	,,	1,250	25
GP4/300	1,750 max. 500 min.	1,250	30
GP4/400	,,	1,000	40
GP4/500	,,	750	50

MOTOR UNITS	I.P. pressure p.s.i.	I/P flow g.p.m.	O/P speed r.p.m.	O/P power b.h.p.
GM2/45	1,850 max.	6	1,500	6
GM2/85	1,550 ,,	9·5	1,500	8
GM3/115	1,400 ,,	14·5	1,500	10
GM3/170	1,450 ,,	19·5	1,500	16
GM3/250	1,400 ,,	30	1,500	22

Dowmatic drive: I/P speed, 2,000 r.p.m.; O/P speed, 2,000–0–2,000 r.p.m. O/P torque, 625 lb. ft.

This hydrostatic transmission is available for applications up to 70 h.p. and many units are already in use. The drive consists (see Fig. 9) of a variable displacement pump and a fixed displacement motor. The pump is of axial-piston tilting-head type, the angle of the pumping elements being altered in order to adjust the stroke of the pistons. The motor uses identical rotating parts, but is set at the maximum angle of 35 deg. An important feature is the braking characteristic, the roles of pump and motor being reversed when the pump angle is reduced. When at zero angle the drive is locked hydraulically. The motor speeds are 0-2,000 r.p.m. in either direction and has a rated maximum torque of 625 lb. ft. at 4,000 p.s.i. The pump input speed is 2,000 r.p.m.

A further range of gear pumps is manufactured and

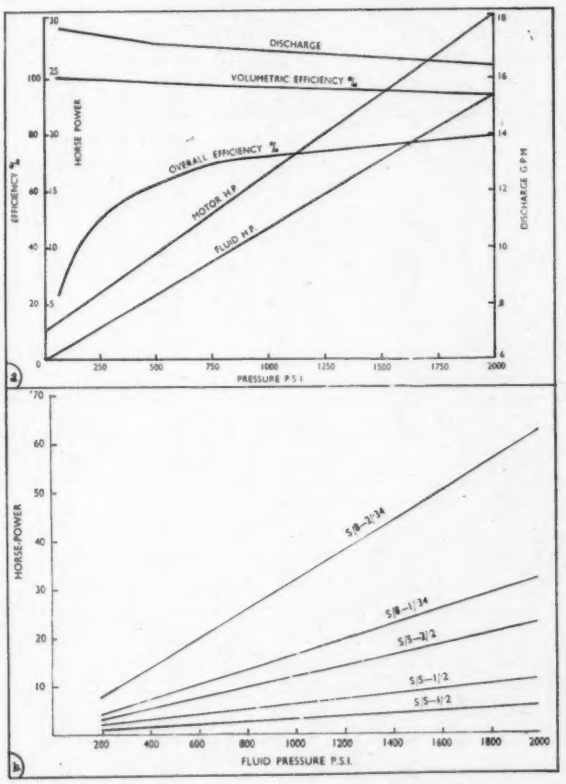


Fig. 11. Performance of Deri Sine (a) pump and (b) motor.

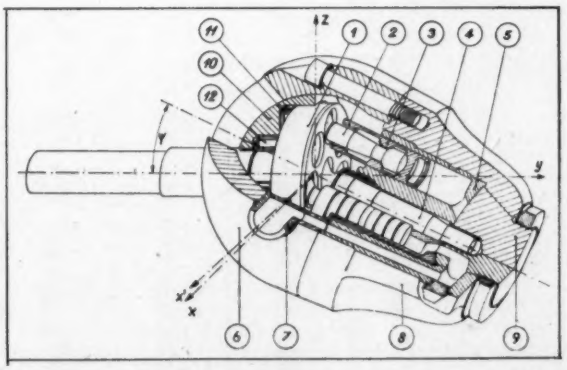


Fig. 12. Typical construction for Hydro-Titan pump or motor.

Table 9

Type	I/P speed r.p.m.	O/P speed r.p.m.	O/P torque, lb. in.	
			Continuous	Intermittent
Standard combined units				
11	970	0–940	105	165
	1,450	0–1,400	105	165
	2,900	0–2,800	105	165
16	970	0–940	280	450
	1,450	0–1,400	280	450
	2,000	0–1,940	280	450
20	970	0–940	570	910
	1,450	0–1,400	570	910
	1,800	0–1,740	570	910
25	720	0–700	1,130	1,820
	970	0–940	1,130	1,820
	1,450	0–1,400	1,130	1,820
32	720	0–700	2,260	3,650
	970	0–940	2,260	3,650
	1,200	0–1,160	2,260	3,650
Remote transmission units (pipe coupled) for fixed capacity motors only				
11	970	0–940	105	165
	1,450	0–1,400	105	165
	2,900	0–2,800	105	165
	970	0–350	280	450
	1,450	0–520	280	450
	2,900	0–1,040	280	450
	970	0–170	570	910
	1,450	0–260	570	910
	2,900	0–520	570	910
	1,450	0–130	1,130	1,820
	2,900	0–260	1,130	1,820
16–16	970	0–940	280	450
	1,450	0–1,400	280	450
	2,000	0–1,940	280	450
16–20	970	0–470	570	910
	1,450	0–700	570	910
	2,000	0–970	570	910
16–25	970	0–235	1,130	1,820
	1,450	0–350	1,130	1,820
	2,000	0–485	1,130	1,820
16–32	1,450	0–170	2,260	3,650
	2,000	0–240	2,260	3,650
20	970	0–940	570	910
	1,450	0–1,400	570	910
	1,800	0–1,740	570	910
	970	0–470	1,130	1,820
	1,450	0–700	1,130	1,820
	1,800	0–870	1,130	1,820
	970	0–235	2,260	3,650
	1,450	0–350	2,260	3,650
	1,800	0–435	2,260	3,650
	1,450	0–170	4,520	7,300
	1,800	0–215	4,520	7,300
25	720	0–700	1,130	1,820
	970	0–940	1,130	1,820
	1,450	0–1,400	1,130	1,820
	720	0–350	2,260	3,650
	970	0–470	2,260	3,650
	1,450	0–700	2,260	3,650
	720	0–175	4,520	7,300
	970	0–235	4,520	7,300
	1,450	0–350	4,520	7,300
	970	0–115	9,000	14,500
	1,450	0–175	9,000	14,500
32	720	0–700	2,260	3,650
	970	0–940	2,260	3,650
	1,200	0–1,160	2,260	3,650
	720	0–350	4,520	7,300
	970	0–470	4,520	7,300
	1,200	0–580	4,520	7,300
	720	0–175	9,000	14,500
	970	0–235	9,000	14,500
	1,200	0–290	9,000	14,500
40	580	0–560	4,520	7,300
	720	0–700	4,520	7,300
	970	0–940	4,520	7,300
	580	0–280	9,000	14,500
	720	0–350	9,000	14,500
	970	0–470	9,000	14,500
50	580	0–560	9,000	14,500
	720	0–700	9,000	14,500
	850	0–820	9,000	14,500

designated in sizes 0-4. Deliveries over this range are from 0·5-50 gal./min. and maximum continuous pressures from 750-1,500 p.s.i.

A simple gear-type hydraulic motor is also manufactured, this being reversible and available in several sizes. Outputs are up to 30 b.h.p., overall efficiencies up to 80 per cent and speeds range from 300-3,000 r.p.m.

A patented system of pressure balancing is used in which oil at inlet pressure is fed to the cavities between the outer end of each bearing and the motor casing. The annular area subjected to pressure is limited by O-ring seals. Pressure in the cavities slightly exceeds the load imposed on the inner ends of the bearings so that the clearance between the bearings (side-plates) and the gear faces is the minimum required for lubrication. This eliminates all the "slip" or internal leakage which normally occurs in some high-pressure units. A metered quantity of fluid lubricates each bearing and is afterwards ducted to a connection in the cover.

English Electric Co. Ltd.

The Sundstrand constant speed drive is a governed mechanical-hydraulic differential transmission, converting a variable input speed to constant output speed, for driving an accessory such as a constant speed alternator. The unit, type AE.8004, is for aircraft application, and consists of a fixed capacity motor connected both mechanically and hydraulically to a variable capacity reversible hydraulic pump. Both pump and motor are of the swashplate type, and are bolted together as one unit; the principles of operation are shown in Fig. 10. The pump cylinder block contains the pistons, the piston rods bearing on the pump swashplate which can be tilted in either direction from a zero position perpendicular to the axis of rotation. The motor cylinder block is similar to the piston assembly except that the

Table 8

Sundstrand	I/P speed: 3,000–8,100 r.p.m. O/P speed: 6,000 r.p.m. O/P h.p.: 50 normal; 75—5 min. intermittent; 100—5 sec. intermittent.

swashplate is mounted at a fixed angle. Both pump and motor cylinder blocks are connected to the input shaft and rotation causes the pistons to reciprocate and oil to flow between the pump and motor. The pressure of the oil delivered to the motor causes the motor swashplate to revolve at a speed relative to the cylinder blocks, the differential speed being governed by the quantity of oil discharged by the pump, this being controlled by the angle of the pump swashplate (see Fig. 10). Thus the angle of this swashplate controls both quantity and direction of flow and is operated through the medium of a governor.

Hydraulic Installations Ltd.

The Hydro-Titan variable transmission system is of two forms. In one case the pump and motor units (see Fig. 12) are connected together by pipelines and in the other the pump and motor units are combined in one casing. Pumps and motors of both fixed and variable displacement may be used in either system, the usual hydraulic drive characteristics resulting from the various combinations. The most compact and versatile unit is the one in which a variable delivery pump is combined in one unit with a variable displacement motor.

By using a motor of variable displacement, a constant horsepower throughout the speed regulation is obtained, the output torque decreasing as the output speed increases. The transmission cannot be reversed. For specific drives,

Table 10

Standard pump types	I/P speed r.p.m.	I/P power h.p.	Max. delivery (cu. in./min.) at 1,100 p.s.i.
11	970	2·0	580
	1,450	2·7	850
	2,900	5·5	1,700
16	970	5·2	1,500
	1,450	7·9	2,300
	2,000	11·0	3,200
20	970	11·0	3,150
	1,450	16	4,750
	1,800	20	5,900
25	720	16	4,750
	970	21	6,350
	1,450	31	9,500
32	720	31	9,500
	970	42	12,800
	1,200	52	15,700
40	580	50	15,200
	720	62	18,900
	970	84	25,400
50	580	100	30,500
	720	125	37,800
	850	147	44,500

Effect of combining different types of units

Type of unit		Speed	Torque	Power
Pump	Motor			
Fixed	Fixed	Fixed	Fixed	Fixed
Fixed	Variable	Variable	Variable	Fixed
Variable	Fixed	Variable	Fixed	Variable
Variable	Variable	Variable	Variable	Variable

stroke adjustment for both pump and motor may be combined to give control of the displacement of both units.

The figures quoted refer to continuous service industrial drives, but where an intermittent drive is required, higher speeds and torques may be used.

Efficiency varies between 80 and 90 per cent, depending on load and speed and also pipe layout. With pump regulation, gentle starting from stationary is possible, but with speeds below 30-40 r.p.m. a constant output torque and a uniform output shaft speed are achieved only by special arrangement.

Table 9 gives a chart of available combined units, with primary (pump) regulation, giving constant torque. Secondary (motor) regulation will give constant h.p. output, while combination gives the fully flexible combined unit mentioned at the beginning of this section. The efficiency of these units varies between 80 and 90 per cent, maximum efficiency being obtained at a ratio of 1:1. With primary regulation, the same slow output speed (30-40 r.p.m.) limitation applies as for the remote transmission units.

Hamworthy Engineering Ltd.

The pumps and motors are pressure-balanced units designed for operation under arduous conditions and are both of the gear-type developed by the Hydreco division of New York Air Brake Co., and made in the U.K. under licence. The speed of the motor varies directly with the quantity of fluid supplied, the torque varying with pressure, and control is applied through external valves fitted in the pipelines. Fig. 13 shows the construction common to both pump and motor and typical performance curves are shown in Fig. 14.

To enable this survey of hydraulic units to be as comprehensive as possible, it is necessary to publish it in two instalments. The second part will appear in our July issue.

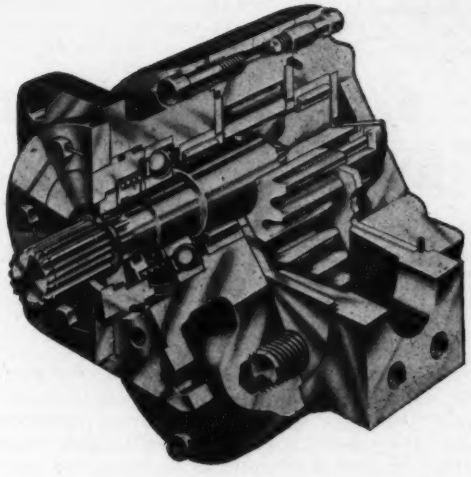


Fig. 13. Assembly of Hamworthy 3000 series pump.

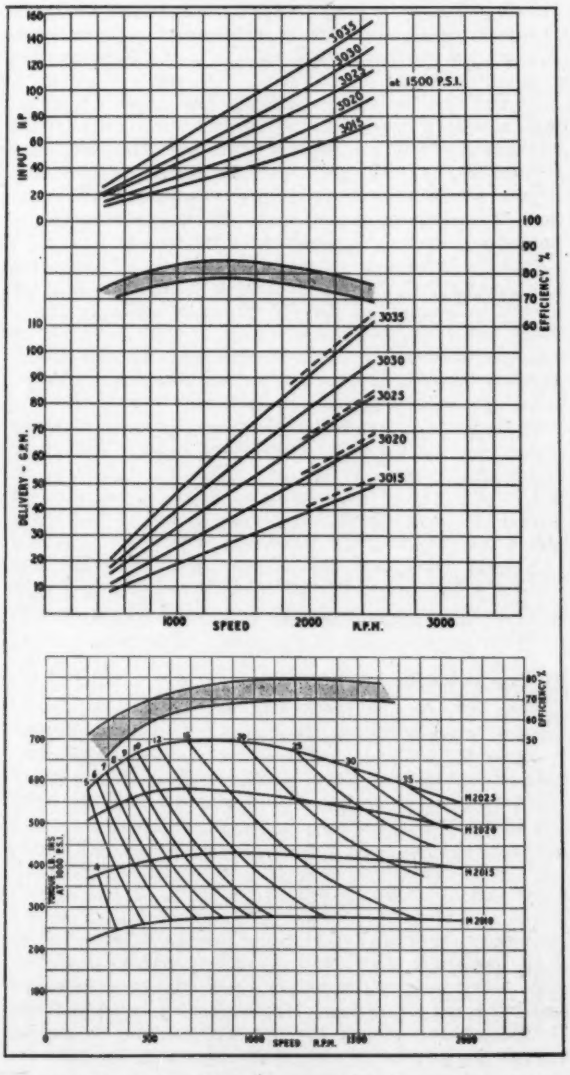


Fig. 14. Typical performance curves for Hamworthy pump and motor.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

New Damping Material

A new noise- and vibration-damping material with important implications for the aircraft/missile industry has been developed in the U.S.A. It is able to control the resonant response of structures exposed to high-frequency vibration and noise experienced in supersonic jets and missiles. High-intensity acoustic energy can cause structural fatigue and is a serious design problem for engineers.

Called Dyna-damp, and produced by the Lord Manufacturing Co., the material employs a specialised form of elastomer which maintains its excellent damping and environmental resistance characteristics over the range from −54 to +120 deg. C.

To be effective, damping material must control response over a wide range of disturbing frequencies. Since most mechanical vibration of airborne disturbances contains many frequencies, some of the frequencies involved will cause a large resonant response in primary and secondary structures. In undamped aircraft structures, this resonant condition can produce amplification of 20 to 100:1, causing failure or malfunction of the structure or equipment mounted on it. Such response may be dramatically reduced through proper use of damped structural elements. Dyna-damp has a resonant amplification of only 3 to 5:1 in structural sections, alternative forms being either laminated panels which may be added to existing structures, or fabricated as complete damped assemblies.

Dyna-damp laminated panels consist of plies of metal plates with the elastomer sandwiched between the plates and bonded to them. Weight of a typical 20 × 20-in. panel is 1·01 p.s.i. This is comparable to an aluminium sheet of similar size, and simulated operational fatigue tests have shown that the life of the panels was over twenty times that of a solid aluminium sheet of equal thickness. The laminated panels can be punched, sheared and formed by the usual stretch-forming techniques employed in the aircraft industry.

Motor Protection Switch

The basic idea of protecting a motor by means of bi-metal strips energised and heated by the motor current is considered suitable under conditions of continuous running. However, with considerable load fluctuations, heavy and very frequent starting, the heating and cooling velocities of the masses (the magnitudes of which vary greatly) become apparent, and the switch cannot give protection against deterioration or increasing temperature of the cooling medium or with blocked cooling ducts.

For this purpose a new thermic guard known as the Sensotherm has been developed by Siemens-Schuckertwerke A.G. This range of bi-metal switches of very small dimensions with minimum thermal inertia properties is embedded and bandaged into the winding heads, thus being in direct thermal connection with the winding, i.e., with the hottest part of the motor. They are produced in fourteen different designs for response temperatures from 50-180 deg. C. with a tolerance of ±4 deg. C. This instrument is held by means of a vibration-proof silicon rubber ring within a copper tube which has a length of 35 mm. and a diameter of 6 mm., the insulation being designed for 3-kV. test voltage.

The switching impulse is effected by either a rest or working contact, and a switch rating of 1 amp. at 220 volts, 50 c/s, is sufficient for most motor protector switches and relays, so that no auxiliary relay is required. Generally, for every winding strand of a multi-phase motor, one thermic protector will have to be provided. Other thermic protectors, set for a lower response value, may actuate optical or acoustic warning signals, so that with sudden reduction of load the drive may be maintained without risk of damage.

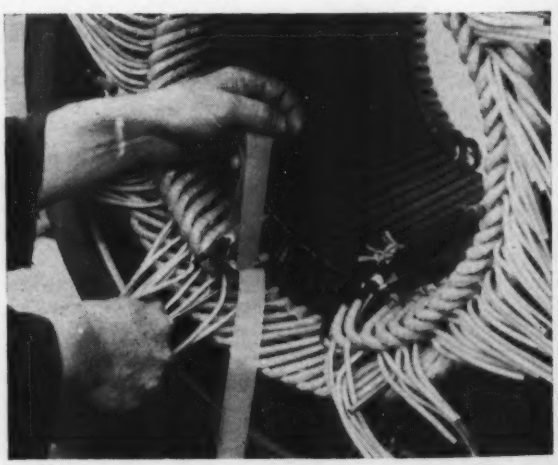
Glass Cloth for Insulation

A new impregnated woven glass fibre cloth for use as an electrical insulating material has been introduced in the U.S.A. by Sun Chemical Corp. The material is described as having high physical strength in relation to its weight, excellent dimensional stability, exceptional tensile strength, low elongation and good dielectric properties, coupled with high resistance to solvents and chemicals. It has been designed primarily as an alternative insulant to varnish-impregnated cotton tapes.

It is called Acto-Glas Mark II and is supplied in the partially-cured stage; when subjected to heat, pressure and time cycles, it becomes a fully cured homogeneous material in the nature of a laminate.

The impregnated cloth can serve in the banding of armatures. The cloth, through its formability characteristics, provides a smooth surface finish without bunching, the woven glass fibre cloth base resisting fraying or tearing.

In other areas the cloth is designed as a replacement for conventional steel banding on medium and large motors.



A Sensotherm switch is here being bandaged into the winding heads of a motor (see "Motor Protection Switch").

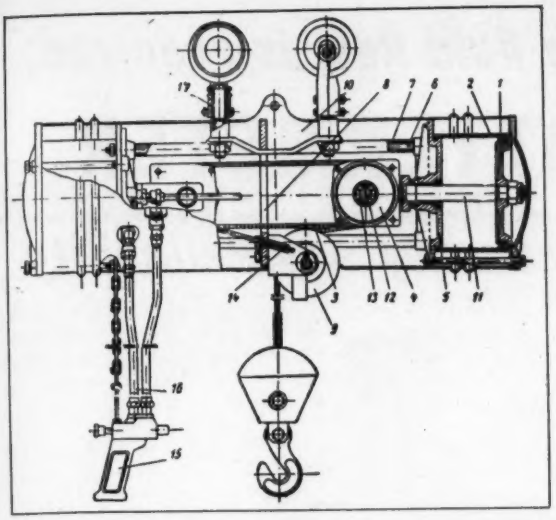


Fig. 1. PP2 type of pneumatic hoist block now being produced in Riga.

Unlike steel, which has a tendency to break at welds through flex fatigue, Acto-Glas Mark II is energy-absorbent. Also, in the past, when steel banding has been used, it was necessary to provide an insulating pad. This new material, being an insulator, dispenses with additional materials.

Electrical coils can be taped with normal tensions being applied, as due to the thermosetting properties of the impregnated cloth it shrinks during the curing operation, thus becoming extremely secure and snug-fitting around the coil, excluding all air. Perfect insulation is said to be further assured by the fact that the cloth is tacky in its partially cured form, and during the taping each successive layer adheres to itself. Fully cured, the tape offers a hard, smooth, non-rusting, corrosion-resistant finish (like a laminate) and becomes virtually impregnable to moisture, chemicals or solvents.

The impregnated cloth is currently being produced with either a polyester or epoxy resin. The temperature class of the polyester is 130 deg C., the epoxy having higher operating temperatures ranges—in excess of 150 deg. C. Curing time cycle for polyester impregnated cloth is 3-15 min. at temperatures of 120-150 deg. C.

Pneumatic Hoist Block

The Soviet turbine engineering works in Riga has started batch-producing a new type of pneumatic block. Altogether, ten models are being manufactured, differing in lifting capacity and in the number of pulley pairs in the block. Fig. 1 shows a sectional drawing of the PP2 type (of 400 kg. lifting capacity).

The moving element of the hoist consists of two horizontally-opposed pistons (1) and cylinders (2) which are linked by a steel wire rope (3) wound around a multi-sheave pulley block (4). The cylinders are attached to the flanges (5) which are joined by tie rods (6) with distance pieces (7). Near the centre there is an intermediate ring (8) with the guide pulley (9) below it and the trolley (10) above. The pistons are attached to rods (11) whose opposed forked ends carry the multi-pulley blocks. According to the size and type, the block consists of three to six pairs of pulleys mounted on the axles (12) on assembled rollers which constitute rolling friction bearings without cages for each individual pulley, since the angular speed of adjacent pulleys is different. The steel wire rope is taken over the pulleys of the block, one end being attached to the intermediate ring (8) by means of a wedge (14).

As compressed air enters the working sides of the cylinders between the flanges and the pistons, the latter move in opposite directions and, in turn, extend the block. The displacement of the cylinders is transmitted to the hook. Lifting and lowering control is carried out by means of valves contained in a handle (15) suspended from the chain with which the hoist is pulled along the beam. The maximum air pressure required for most of the ten models amounts to 8 atm.

The hoisting speed ranges from 3 m./min. in the case of the 400-kg. model (maximum lifting height of 1·2 m.) to 12 m./min. in the case of the 125-kg. model (maximum lifting height of 2·4 m.).

Acrylic Resin for Lenses

Of the available acrylic resins, the methacrylate polymer has so far obtained the greatest usage for lenses and, despite a surface hardness greatly inferior to that of glass, it has been employed as a substitute in sunglasses because it is easy to colour.

Another group claiming attention in the U.S.A. are the derivatives of allyl alcohol, particularly the diallylglycol carbonate, i.e., resin CR 39, which has characteristics of high hardness, good resistance to abrasion and interesting mechanical properties. Although the shock resistance and other properties were found to be inferior for use in the optical industries, the basic characteristics showed promise; the French company, Lentilles Opthalmiques Specialise, has conducted prolonged research on a resin of this group suitable for optical lens production, resulting in the production of a resin known as Orma 1,000.

The properties of the resin are as follows:

Specific gravity at 25 deg. C.:	1·32
Refractive index at 20 deg. C. n_D:	1·498
n_C:	1·495
n_F:	1·504
Dispersion factor $\frac{n_D - 1}{n_F - n_C}$:	55·3
Max. temp. in continuous service without load:	100 deg. C.
Coeff. linear thermal expansion per deg. C., 25-50 deg. C.:	10·7
Rockwell hardness:	M 95- M100
Tensile strength (kg./sq. mm.):	3·5-4·2
Modulus of elasticity (tensile) kg./sq. mm.):	200

Comparative tests were conducted on lenses manufactured with the two materials previously used, mineral glass and methyl polymethacrylate, and on lenses made from the Orma 1,000 resin. Abrasion tests corresponding to normal wiping of spectacle lenses were conducted and no trace of wear was encountered with normal mineral glass after ½-hr. of rubbing. The same result was obtained with the Orma 1,000 resin. The polymethacrylate resin, however, was found to be strongly marked after 5 min. of testing.

A second series of abrasion tests was then made by means of a jet of emery powder projected on the convex surface of the lenses under a pressure of 200 gm., these tests broadly corresponding to the wear resistance caused by dusts. Glass was depolished nearly to the same extent as the Orma resin (ratio of relative depolishing falling between 0·9 and 1·2), the polymethacrylate resin suffering a depolishing action nine to twelve times greater.

Another important point claimed is the impact (shock) resistance, and tests, made by means of an apparatus of the ball-drop type, showed that Orma and polymethacrylate resins were both superior to glass.

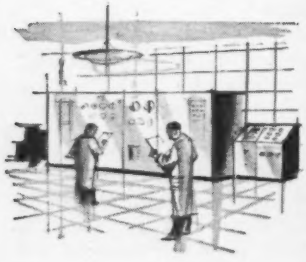
With Orma resin the normal solvents, ethyl alcohol, petrol, benzene, toluene, acetone and trichlorethylene, had no effect.

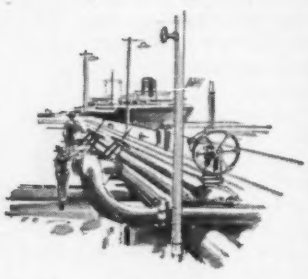
EMD 2905 for further information

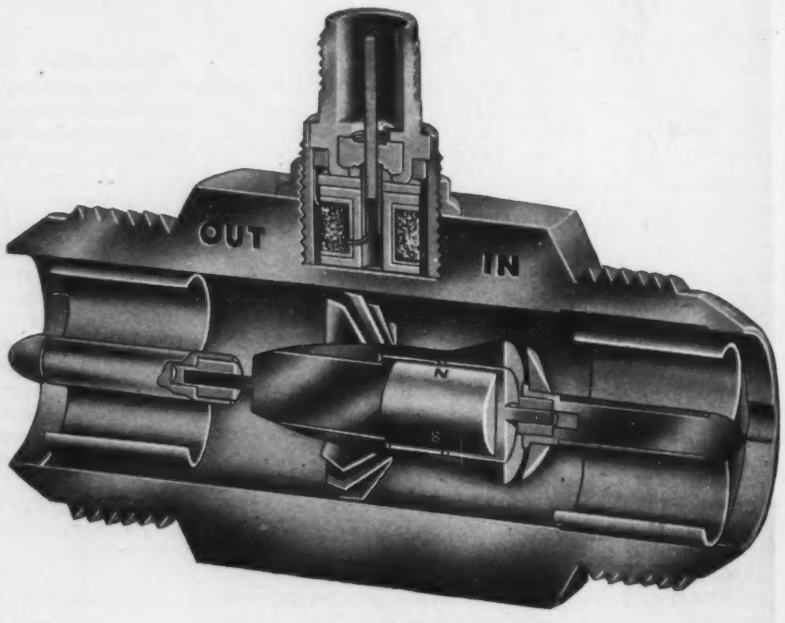
Wherever information on fluid flow is required,

the de Havilland POTTERMETER

sets new standards of accuracy and reliability







This new turbine-type flowmeter enables major advances to be made in the techniques of flow measurement and control. The de Havilland Pottermeter is the only flowmeter which offers all these features:

- **Accuracy to ± 0·1% or better on repetition work, ± 0·5% or better over a 20·1 range. Calibration remains constant for a variety of liquids over wide flow ranges.**
- Contains only one moving part — no thrust bearings — operates with a minimum of maintenance at high temperatures and pressures.
- No larger than the pipeline in which it is installed — may be mounted in any attitude.
- Can be supplied with indicating, recording and process control equipment — gives digital presentation of results.
- Can measure volumetric or mass flows.
- Models available to measure flows from 0·1 to 40,000 Imperial gallons per minute, at a wide range of operating pressures. Larger and smaller sizes made to order.
- Can measure flow of any liquid or gas, irrespective of its lubricating or non-lubricating properties, at temperatures ranging from -455°F to 1500°F.
- Manufactured as standard in stainless steel — can be made in any non-magnetic material.
- Rapid response rate permits transient flow studies.

The de Havilland Pottermeter will be demonstrated on
STAND Q.730
at the
I.E.A. EXHIBITION
Olympia
May 23 to 28

Write now for further details to:

DE HAVILLAND PROPELLERS LIMITED
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DESIGN FOR THE SENSE OF TOUCH

IN the design of complex control panels, an operator is confronted with a large and often confusing array of controls and displays. The importance of designing controls so that they are readily identified and distinguished has been borne out by documented surveys of accident causes.

The designer, in simplifying the operator's task, can use a number of techniques to help differentiate the various controls and their respective functions. Location and spacing of controls is one means of coding. Another coding technique is to colour the controls so that the operator learns to associate a certain colour with a given function. Still another coding device is to vary the size of the controls.

Considerable research has gone into identifying control shapes that can easily be distinguished by the sense of touch. One study showed that the shapes depicted in Fig. 1 are easily distinguished practically 100 per cent of the time. Using these control shapes, the operator can easily distinguish between the various available controls by touch; but, whenever possible, shapes should be selected which impart some type of meaning or hint of the function involved.

Various geometric forms would be applicable in limited situations, but would not possess the important sequential and combination characteristics of letters and numbers.

The most important consideration, however, in selecting tactual stimuli is that in terms of economy of design effort, cost and panel space it would be most efficient to have one and the same stimulus serve both the visual and tactual senses. In view of these considerations, the most opportune tactual stimuli to use would be raised versions of the standard alphabet and numbering systems.

Exploratory research work on this problem was concerned with stimuli large enough to be inscribed in a $\frac{1}{2}$-in. circle. The letters and numbers were raised $\frac{1}{4}$ in. from a surface and each character had a constant stroke width of 2 mm.

The results of this research showed that it is feasible to use relatively small tactual stimuli to communicate with a high degree of accuracy. Of the thirty-four letters and numbers tested, twenty were identified 90 per cent of the time or better.

This research is just a start, since further study is necessary to determine the optimal height, width, stroke width, height/width ratio/and letter style for a complete "touch" alphabet and number system. Further study is also needed to determine the accuracy and time to read complete words and sentences utilising tactual alphabet.

In connection with the tactual discrimination of letters and numbers, certain pertinent facts have been uncovered. Males and females perform equally well tactually and it makes no difference if the operator is right- or left-handed. The individual performs equally well using any of the four right-hand fingers (excluding thumb), pressures of 0·3 oz. usually being exerted in making the discriminations. A short training period results in marked increases in accuracy and a decrease in time of reaction.

Some exploratory work also has been done with the possibility of using varying surface textures as a technique for distinguishing between equipment components. In this study ten differing textures were selected at random and were tested for distinguishability by blindfolded subjects. The results of this study showed that three of the surfaces tested were promising. A surface with $\frac{1}{4}$-in. hemispheres raised $\frac{1}{4}$ in. from the surface and one consisting of abrasive flint paper were accurately discriminated 100 per cent of the time. A third surface texture consisting of jewel abrasive cloth produced an accuracy of 90 per cent.

Further research is necessary to identify other surfaces which can serve for texture coding. This technique appears suitable for situations where it is important that the front or back, top or bottom of an item be clearly differentiated in the absence of visual cues.

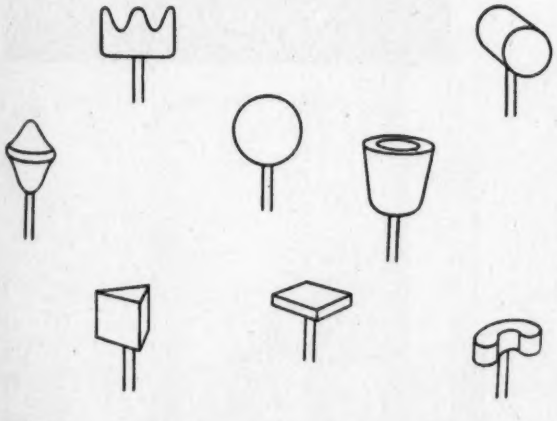


Fig. 1. Shapes such as these used for control knobs have been found in research work to eliminate error of selection in all cases.

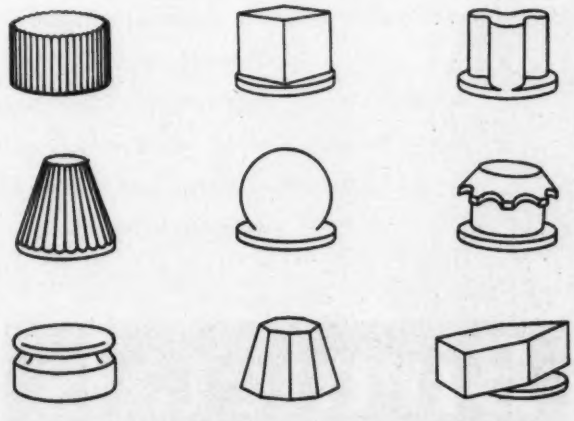
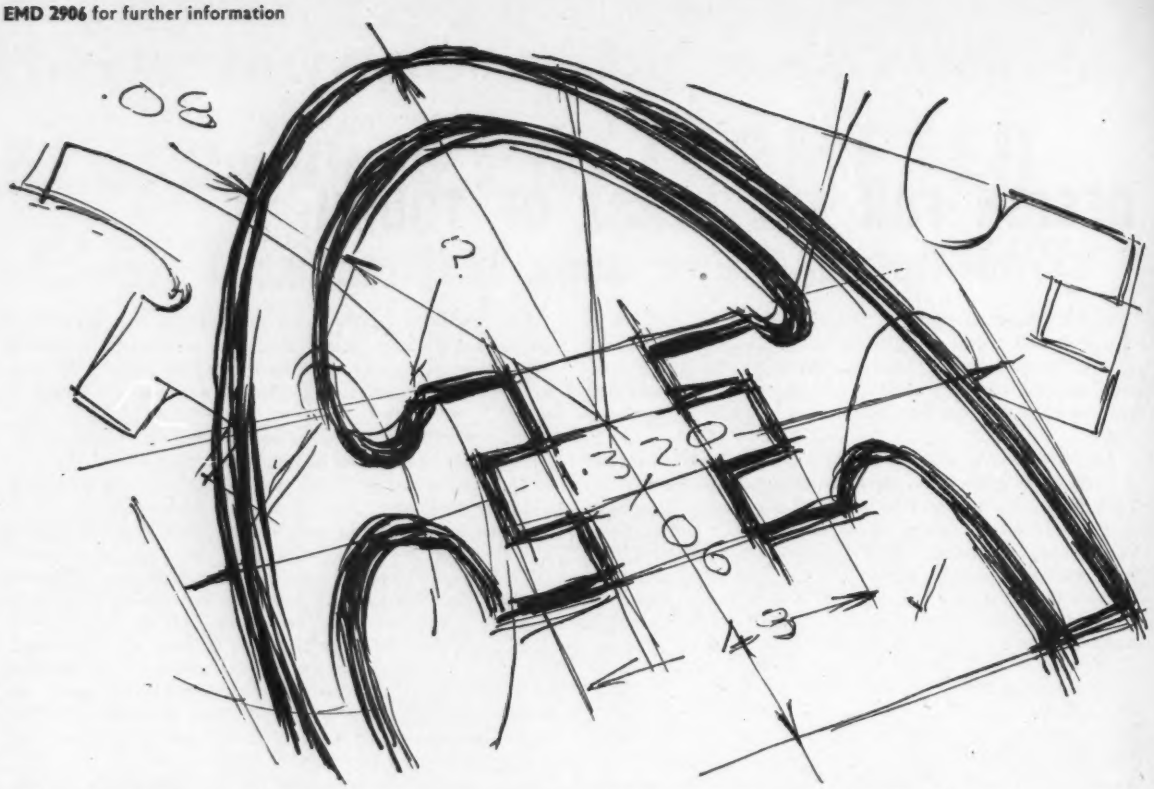


Fig. 2. (Left) Knobs which must be rotated more than one full turn; (centre) less than one full turn; and (right) where correct position of knob must be seen.

EMD 2906 for further information



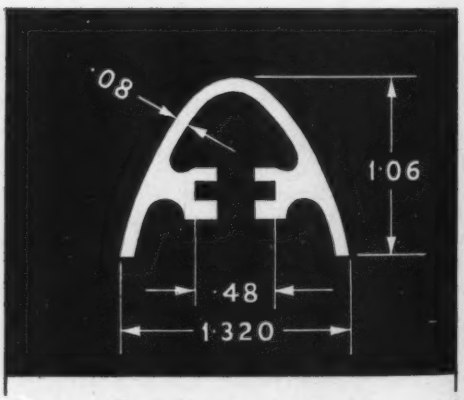
the designer and the doodle

Extruded sections allow the designer great flexibility in his approach to a problem, and because aluminium alloys are easily worked designs can be executed by the extrusion process without heavy tooling costs.

Our advice on designs is given without obligation, and the best time to bring us in is right at the beginning.

So even if you have an idea that is no more than a doodle, why not doodle it in the space next to our example and get us to comment on it?

Designers are invited to send for a copy of our standard sections catalogue.



Sketch dimensioned section here

BM267

Birmetals

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

COMPARATIVE PROPERTIES OF FIVE SHEET MATERIALS

Engineering Materials and Design

DATA SHEET No. 38

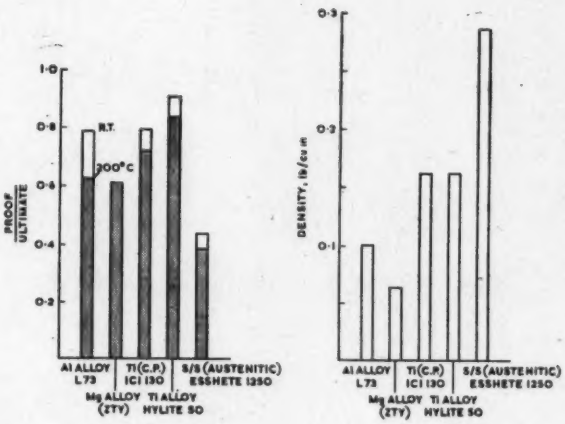
The values given are comparative. For absolute values reference should be made to the relevant manufacturers:

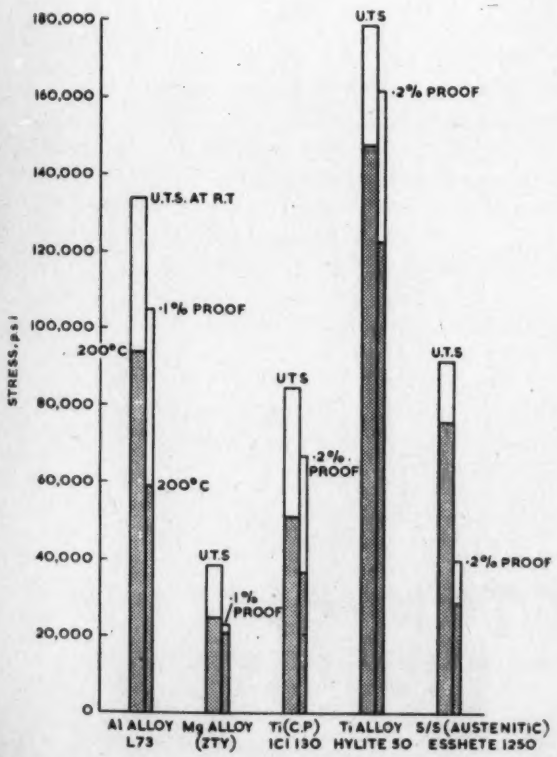
Aluminium alloy to BS.L73	High Duty Alloys Ltd.
Magnesium alloy (ZTY)*	Magnesium Elektron Ltd.
Titanium, commercially pure (ICI.130)	Imperial Chemical Industries Ltd.
Titanium alloy (Hylite 50)†	Jessop-Saville Ltd.
Stainless steel (Esshete 1250)† ...	Samuel Fox & Co. Ltd.

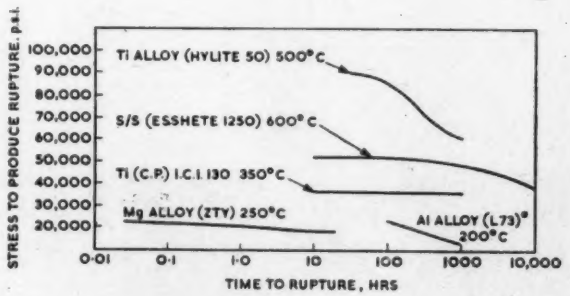
* Normally used in plate form and is essentially a short-time material at elevated temperatures.

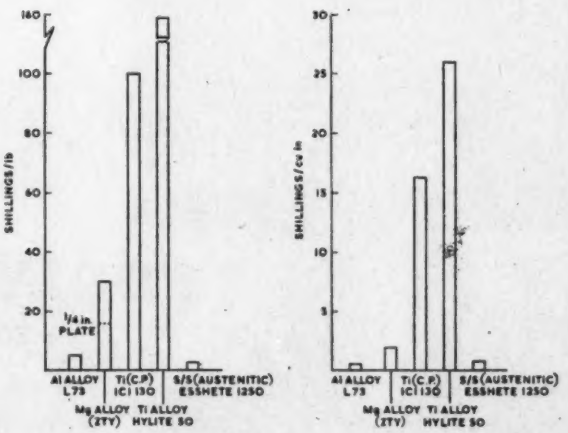
† These materials are normally used in bar form.

Costs are approximate only and depend on gauge, tolerance flatness, quantity and inspection. In general, the figures given relate to sheet of 18 S.W.G. and for minimum quantities.






STRESS TO PRODUCE RUPTURE, p.s.i.
Ti ALLOY (HYLITE 50) 500°C
S/S (ESSHETE 1250) 600°C
Ti (C.P) I.C.I. 130 350°C
Mg ALLOY (ZTY) 250°C
Al ALLOY (L73)* 200°C
TIME TO RUPTURE, HRS



EMD 2907 for further information

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians. Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipe-work is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

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DEFLECTION OF CYLINDER ENDS AND DISCS UNDER UNIFORM LOAD

Engineering Materials and Design
DATA SHEET No. 39

Solutions for the thickness of a cylinder end are:

Flat cylinder bottom

$$t = 0{\cdot}405\, D\sqrt{\frac{P}{S}} \quad \text{(Based on Reuleaux's formula)}$$

Semi-spherical cylinder bottom

$$t = \frac{P\,D}{4S}$$

where t = thickness, in; D = diameter, in.; P = working pressure, p.s.i.; S = maximum permissible stress in material.

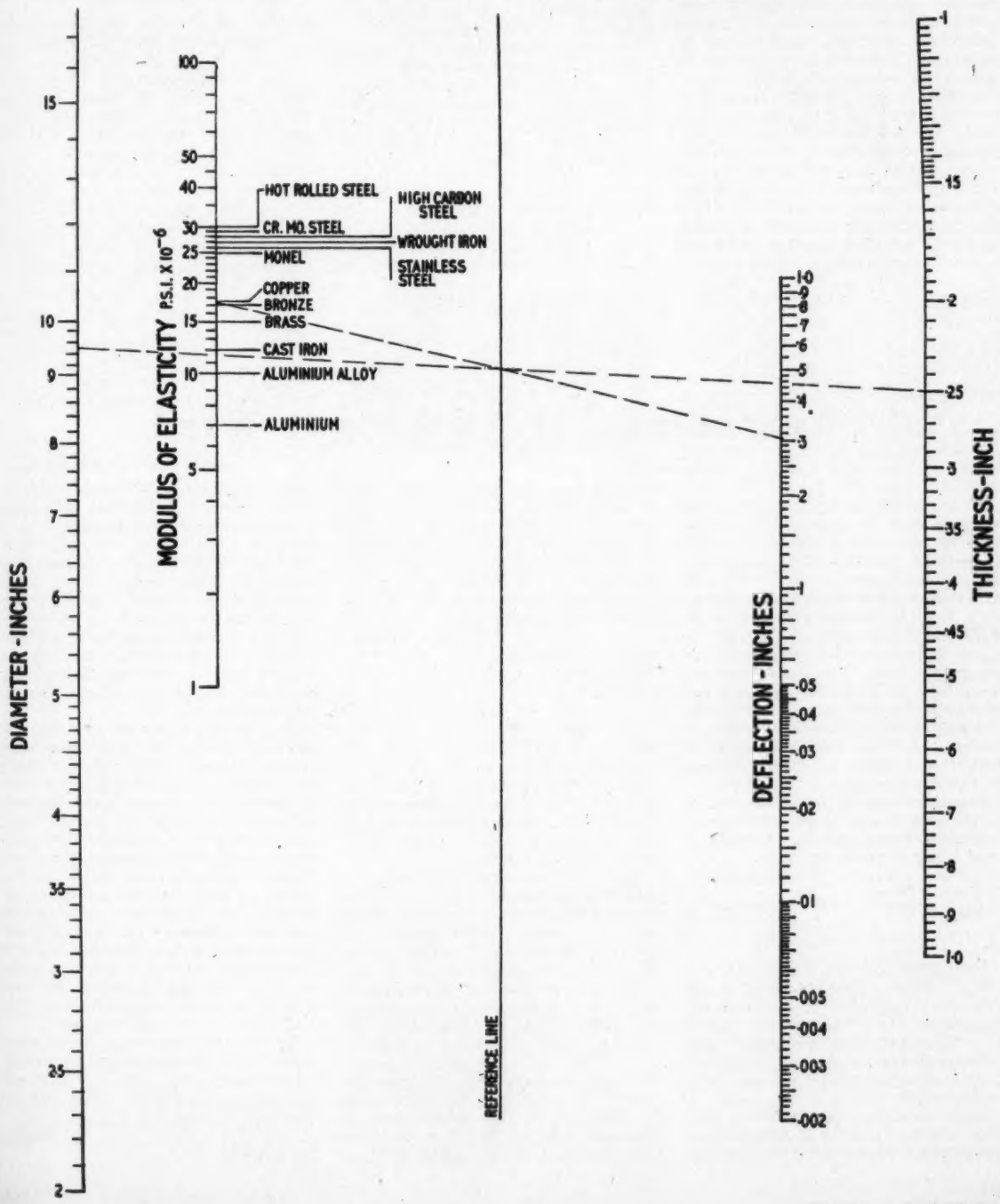
The nomogram gives solutions for the centre deflection of a flat circular disc secured at the edges and subjected to a uniformly distributed load. The two outer scales are always used together; and likewise the two inner scales. Thus, always connect the diameter and thickness scale values; and then, separately, the modulus of elasticity and deflection scales, through the same point on the reference scale.

Values of deflection given by the nomogram are for a uniform pressure of 1,000 p.s.i. For any other loading the deflection value obtained is factored accordingly. None of the other scale values may be factored on the nomogram.

Example : To find the deflection of the centre of a 9½-in.-dia. copper disc uniformly loaded at 450 p.s.i. Disc thickness is ¼ in.

Connect diameter value to material thickness. Through the same point on the reference scale, project a line from the appropriate point on the modulus of elasticity scale to cut the deflection scale. Read value of deflection = 0·305 in. This applies to a uniform load of 1,000 p.s.i.

Thus for 450 p.s.i. loading, centre deflection = 0·45 × 0·305
= 0·138 in. (answer).



Data sheet by R. H. Waring

New Books

Theory of Elasticity. *By L. D. Landau and E. M. Lifshitz.* (*Pergamon Press, 40s.*)

THIS book is a translation from the Russian text-book which forms part of the Theoretical Physics series by Landau and Lifshitz, who are recognised as two of the world's outstanding physicists.

The authors use tensor notation throughout and, consequently, readers unfamiliar with tensor calculus will probably find reading rather difficult at first, as the various equations of elasticity may not be recognised. Nevertheless, since only a rudimentary knowledge of tensors is required, this book could, in fact, be used as an introduction to the use of tensors in the theory of elasticity.

It is surprising to find so much information packed into only 134 pages. The topics covered in this volume include fundamental equations of elasticity, strain energy, plates and shells, torsion and bending of rods, stability of elastic systems and propagation of elastic waves. The concluding chapter includes also some topics not normally found in text-books on the subject, such as thermal conduction, viscosity and sound-absorption in solids.

A valuable feature of the book is the large selection of illustrative problems for which the methods of solution are briefly described.

J. S. Przemieniecki

Aluminium Bus-bar. *By A. G. Thomas.* (*Hutchinson, 21s.*)

This book makes a timely appearance, since little authoritative information is generally available on the subject apart from papers before institutions.

The book deals clearly with electrical effects, e.g., power loss, skin effect, reactance, etc., and with the practical aspect of clearance proximity effects, heating and loading. Formulæ are given and comprehensive tabular data on the various sections which can be used.

Scientific Russian. *By George E. Condoyannis.* (*Chapman & Hall, 28s.*)

The impact of Soviet technological advances is reflected by the number of people learning the Russian language. For the technician there is the added difficulty of technical terms and phrases. This book is intended to fulfil the needs of this group and while it can be used by those with no previous knowledge, it is likely to be complementary to Russian primers. It should not be regarded as a dictionary of terms, but rather as a grammar with emphasis on Russian technical terms and phrases.

British and Foreign Specifications for Steel Castings (Part 1). (*British Steel Castings Association, 40s.*)

This book summarises the requirements for steel castings in Austria, Belgium, France, Germany (West and East), Sweden, Switzerland and the U.S.A., and indicates the nearest comparable British specification. Lists of standards current in Czechoslovakia, Holland and Italy are also provided, but in less detail than those for the former countries, the tables for which indicate both chemical composition and principal mechanical properties.

LETTERS TO THE EDITOR

Searching for the Right Word

Sir,

I was naturally intrigued by the leading article in your April issue, "The British Have No Word For It". To acquire depth of meaning, a word must be born naturally, not artificially coined. The lack of a suitable word is merely a confirmation of a lack of national attention to the work involved in engineering design.

If a word must be coined, I can only suggest the word "constructor", already in use for those responsible for the design of ships and aircraft. It has a much wider connotation on the Continent, where it implies the truism—which we seem to neglect—that design and management, to be effective, cannot be far separated.

Good management in engineering involves good design as its primary consideration, if only to have something in hand which is worth managing!

Hugh Clausen

17 Harman Drive,
London, N.W.2

Sir,

Some years ago the G.P.O. offered a prize to anyone submitting a concise and satisfactory alternative to the somewhat monstrous term "telecommunications". The word persists, however, and I fancy a similar fate awaits the title "design engineer", despite the logic of your April leading article.

Design engineers, like inventors with whom they have so much in common (both being skilled in the art of continually evolving newer and better results), follow a profession of the highest intrinsic merit. . . . But let us call a spade a spade —and be proud of it, if pride is necessary to the younger ego. An apt and honest title is just as worthy of pride as is that indispensable prerequisite of all top-rungers—the drawing-board.

J. R. C. Moore

Speciality Instruments,
Little Melton,
Norwich.

Sir,

Drawing is not design, but the type of education and the climate of opinion in Britain are so strikingly different from those in other countries that it is no wonder the drawing-board is seen in completely different perspective. . . .

There are some signs of a change in outlook in engineering in general, but not in engineering design in particular. When one talks, however, of the status of engineering designers, I cannot help feeling that much of the trouble lies in the lack of definition of the term. There might be some benefit in inventing a new term, but this would have to be defined; surely the definition could equally well be used for the existing term "engineering designer"? No doubt many readers could give their versions of a definition, but these might be more confusing than helpful, since all would be different. Surely it would be better if some body representative of engineering designers (!?) gave a lead by putting forward a definition which had a chance of being generally agreed to, in much the same way that the terms "professional engineer" and "engineering technician" have been defined by the senior engineering institutions. A proper definition is useful not only in the interests of effective communication; it would lead naturally to advances in education and training indirectly, or even directly if the definition were partly in terms of education and training.

It is, in any case, surely necessary to establish whether the term "engineering designer") or any other term substituted for it) is a specific one or a generic one. Experience has already shown that one cannot win recognition for a generic term, such as "engineer", which is why the two specific terms "professional engineer" and "engineering technician" have been invoked. In short, we do not know yet whether the expression "status of the engineering designer" has any real meaning. It depends upon whether the term "engineering designer" has a specific meaning, like "train driver" or "bus conductor", or some vague meaning, like "average man" or the "taxpayer".

My own impression of the current scene is that we are, perhaps unconsciously, trying to build a new order out of an old out-grown one, but we do not quite know what we are doing.

P. J. Booker

London, W.1.

WHAT'S NEW IN MATERIALS & COMPONENTS

Miniature Thermocouple Wire

Additions to the range of Thermocoax miniature thermocouple wire have been announced.

Grade 2BB Ac 10 consists of two wires of Alumel in a stainless-steel sheath with an overall diameter of 1 mm. This material can be used—with two junctions of Chromel-Alumel—for measuring differential temperatures. Grades 2AB Ac 15 and 2AB Ac 20 are Chromel-Alumel wires in a stainless-steel sheath with overall diameters of 1·5 mm. and 2 mm. respectively. Grade 1 Nc I 05 is a heating element of Nichrome in a Inconel sheath with an overall diameter of 0·5 mm.

Thermocoax wire has been specially designed for measuring a very wide range of temperatures under extreme conditions, e.g., surface and working temperatures of all kinds of heat-treated materials, of furnaces, working machine parts, and heating and cooling installations. It is particularly suitable for use in atomic energy plants, steel mills and other applications where an alternative temperature measurement method would be impracticable. Research & Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.

EMD 2991 for further information

Thermocouple materials

Accuracies of 1 per cent below and ¾ per cent above 400 deg. C. are said to be obtainable from the first of some new mineral-insulated thermocouple materials now available. Accuracies up to three times as good are available to special order. Supplied separately or made up into thermocouples, the new material is suitable for use throughout industry, except in the nuclear field.

Initially, there are two materials, Chromel/Alumel (made by Hoskins Co.) and T1/T2, the wire sizes being 0·020 and 0·010 in. respectively, and overall sheath diameter 0·122 and 0·060 in. Resistance per foot for the Chromel/Alumel is 1·1 ohms (positive conductor) and 0·44 ohms (negative); resistance per foot for the T1/T2 is 4·6 ohms (positive) and 1·85 ohms (negative). Insulation resistance is 100 megohms minimum.

The material can be supplied with ends sealed and no junction made, or alternatively as thermocouples having one hot junction, with or without mounting attachment. A thread is supplied as standard at the cold end. Honeywell Controls Ltd., Greenford, Middx.

EMD 2992 for further information

Oil-resisting Finish

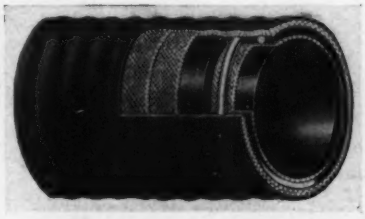
Armour 1172 has recently been introduced as an air-drying gloss finish claimed to be resistant to transformer, lubricating, diesel and certain cutting oils. Suitable for exterior exposure, it is also said to be resistant to mildly acidic or alkaline conditions and to be able to withstand temperatures up to 140 deg. C.

Its main applications are in the engineering industry, where it is suitable as a coating for sumps, the interior of transformer tanks, and the exterior surface of petrol tanks. But it is also suitable for use wherever a rapid-drying gloss finish with rapid set is required. It is capable of being force dried, which is said to enhance the gloss.

Available in black and 631 light battleship grey, application is by brush, dip or spray, direct on clean metal. It touch-dries in 20 min. and hard dries in 2 hr. or in a shorter time if force dried. Griffiths Bros. & Co. (London) Ltd., Armour Works, Well Lane, Wednesfield, Staffs.

EMD 2993 for further information

Dry Materials Hose



To the range of available industrial hoses has been added a lightweight, flexible hose specially built for the bulk handling of dry materials which are not highly abrasive. It is said to be particularly well suited for the handling of grain, dry chemicals in crystal powder form, fertilisers and similar materials.

The hose (Style 273 x 243) is supplied in lengths to suit the site and application. It can be built with enlarged ends for fitting couplings or with soft ends for clipping to existing pipework or hopper feed tubes. The seamless ⅞-in. smooth-bore tube of high-grade rubber is reinforced by three plies of strong, close-woven fabric and a helix of round steel wire embedded in the rubber, while the cover consists of a medium-gauge, abrasion-resisting compound. The hose has a maximum working pressure of 50 p.s.i. and is supplied in bore sizes of 2½ and 4 in. Goodyear Tyre & Rubber Co. Ltd., Bushbury, Wolverhampton.

EMD 2994 for further information

Improved Anti-rust

A new anti-settlement agent has been introduced into Rust-Anode, the anti-rust cold galvaniser. This means that practically no stirring is needed before application, which saves valuable time, particularly when large quantities are being used.

In tests carried out by the makers, tins of Rust-Anode containing the new agent have stood for over seventy-five days, and there was no appreciable settlement. The zinc is unaffected by the new agent, and Rust-Anode dries even harder than it did before.

Rust-Anode is a metal coat that is applied to steel surfaces by brushing, spraying or dipping. It leaves a coat of pure zinc, which is strongly adherent, ageproof and rustproof. It can be applied under paint for additional protection. C. & P. Development Co. Ltd., Wiggie Works, Redhill, Surrey.

EMD 2995 for further information

Thermosetting Tape

Details have recently been announced of a new high-temperature tape known as Transonex Thermosetting melinex tape.

Based on I.C.I.'s 0·001-in. melinex film, the tape has an extremely stable, key-coated thermosetting adhesive. It carries a guaranteed storage life of twelve months.

Following curing at recommended temperatures, Transonex Thermosetting will operate up to 180 deg. C. without deterioration.

It is said to have first-class electrical properties, a high tensile strength, excellent resistance to acids and alkalis and can be employed on applications involving solventless impregnation and varnishing. The tape is available in a range of standard widths in 72-yd. rolls on 3-in. cores. John Gosheron & Co. Ltd., Albert Embankment, London, S.E.11.

EMD 2996 for further information

Sealing Material

Texolag base type 1 is employed for the sealing of regular shapes (e.g., pipes and cylindrical vessels). The material consists of plain weave cotton cloth coated and impregnated with a specially formulated vinyl compound, and is supplied in roll form. It is said to have excellent resistance to oils, aliphatic hydrocarbons, alcohols, dilute acids and alkalis. Tensile strengths of not less than 60 p.s.i. (weft) and 70 p.s.i. (warp) are claimed. The material is normally used in conjunction with an adhesive compound. R. A. Brand & Co. Ltd., Works Road, Letchworth, Herts.

EMD 2997 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

EMD 2910 for further information

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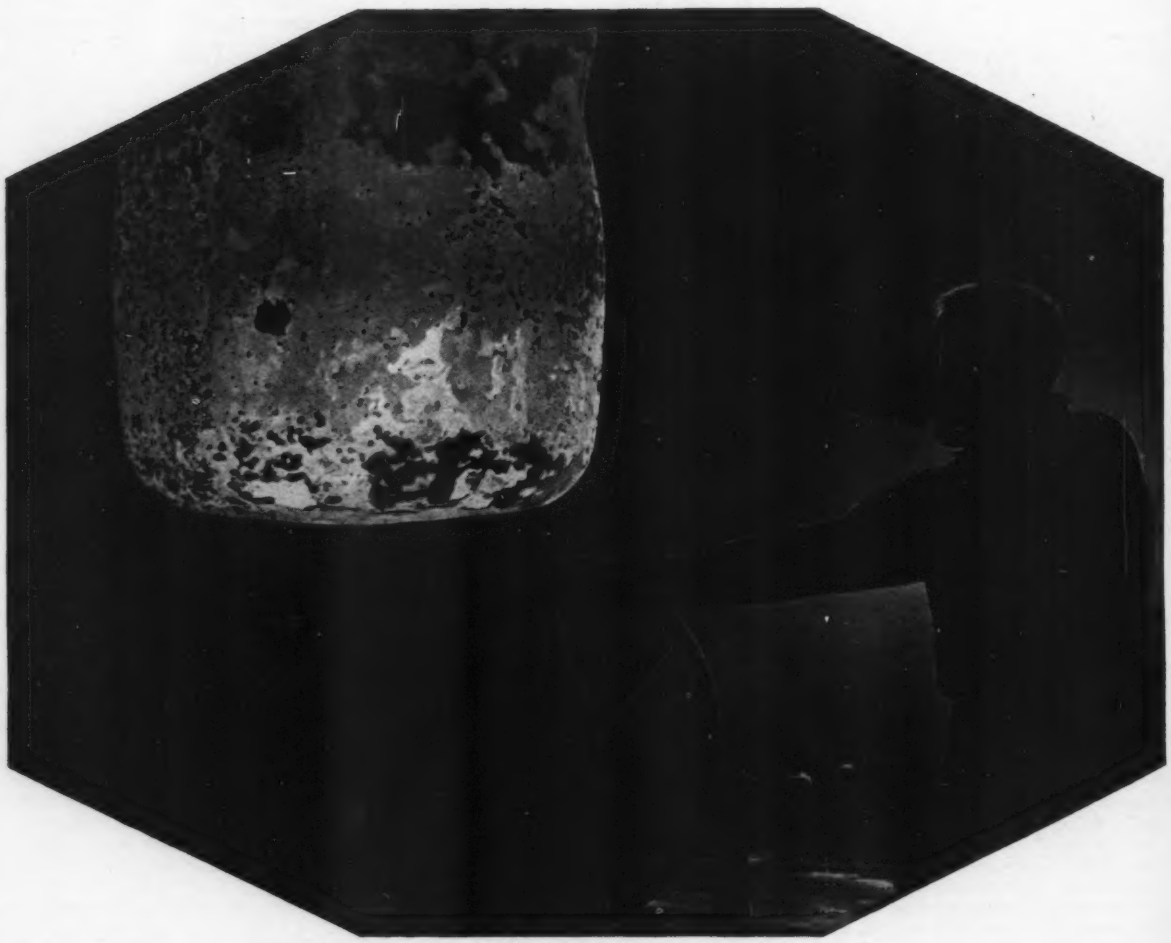

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High-density Polythene

Three new types of Rigidex high-density polythene have been announced. They are copolymers of ethylene with other olefins and are designed for use in applications where better resistance to stress-cracking and superior load-bearing properties are required.

The new types are: Type 3, which has the best mechanical properties and resistance to stress cracking; Type 12, which combines good processing qualities with good all-round physical properties; and Type 40, which is an easy-flow grade designed for injection moulding difficult items. Types 3 and 12 can be moulded round metal inserts, a factor of importance in injection moulding. In general, the Rigidex copolymers have a slightly lower softening point and tensile strength and they are a little more flexible than Rigidex homopolymers.

Applications for Type 3 include blown bottles (particularly where maximum stress-cracking resistance is required), blown film for boilable packs, etc., cable insulation, monofilaments where the best creep properties are wanted, and industrial mouldings calling for maximum impact strength and stress-cracking resistance. British Resin Products Ltd., Devonshire House, Piccadilly, London, W.1.

EMD 2998 for further information

Insulated Decking

Galvanised steel decks are now available with permanent-colour plastics soffits. To be marketed under the brand name of DecoRdeck, the new units are fabricated from a laminate of galvanised steel sheet and coloured polyvinyl chloride.

Retaining all the characteristics of the Ruberoid-insulated metal deck roof, DecoRdeck is said to provide an attractive and extremely durable built-in ceiling that is easily cleaned with soap and water, is abrasion-resistant and incombustible. Colours available are light green, light blue, yellow, red, grey, cream and white, while others can be supplied by arrangement.

It is virtually impossible for the p.v.c. and the steel sheet to delaminate—stability being assured in temperatures of up to 110 deg. C. and, for limited periods, up to 180 deg. C. The Ruberoid Co. Ltd., Commonwealth House, 1/19 New Oxford Street, London, W.C.1.

EMD 2999 for further information

Thermal Neutron Shielding

A specialised technique has been developed for the production of new thermal neutron shielding materials with vastly improved formability. It will be known as the Hiduminium 400 series. The product consists of boron carbide (B_4C) of suitably fine mesh size, evenly dispersed in a fully wrought aluminium matrix, clad on both sides with high-purity aluminium. This material differs radically from conventional Boral, which is produced by a powder metallurgy technique and is non-formable.

A method has been perfected by which the B_4C particles can be uniformly suspended throughout molten aluminium, followed by semi-continuous casting to a rolling slab which is then clad and rolled in the normal manner. The B_4C used has a purity better than 99 per cent and the concentration in the new material can be adjusted to suit customer requirements.

Typical thermal conductivity values for 15 per cent B_4C material are approximately 320 B.t.u./sq. ft./in./°F. High Duty Alloys Ltd, Slough, Bucks.

EMD 3000 for further information

Simplified Hose Fitting

A new range of Free-End hose fittings embodies an ingenious principle. Enclosed in the fittings is a stainless-steel spring that closes down and grips the hose over 360 deg. The fitting is done completely by hand and is claimed to take only a few seconds. The hose is pushed into the fitting, the locking nut is twisted and a leak-proof joint is made. These fittings are made in polythene, nylon or other plastics, or in brass or other metals for many sizes and wall thicknesses of hose. They

are claimed to be suitable for a large variety of uses and can be used for water and other liquids, compressed air and gases. They are available for industrial and domestic applications, such as pneumatic tools and systems, petrol pumps, fire hoses, washing machines, and also in hard polythene for the garden and farm. Hozelock Ltd., Haddenham, Bucks.

EMD 3001 for further information

Stretchless Belting

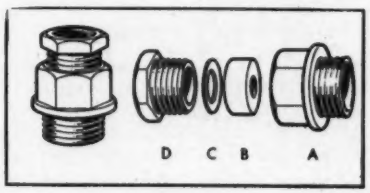
Eight times the strength of leather is claimed for Nycor belting which is now on the market. The belting has a flexible plastics core inside chrome leather covers. The plastics core is said to be stretchless when installed at the correct tension, and may be used on fixed centre drives and on drives where jockey pulleys previously had to be used. The built-in nylon fabric is said to prevent longitudinal splitting and cracking of the core.

Speeds of 10,000 ft./min. may be handled successfully, it is said. Graton & Knight Ltd., Warwick Road, Boreham Wood, Herts.

EMD 3002 for further information

Nylon Cable Glands

A range of cable glands and lock nuts in Grillon, a shock-resisting nylon compound claimed to withstand considerable rough usage and corrosion, is now available. They are suitable for screwing into switch boxes, conduit boxes, fuse boxes, chassis and wherever a weatherproof



entry is required, or as a strain-relief bushing to prevent dragging or chafing.

Each gland consists of four parts: the body portion (A), the rubber gland (B), the metal washer (C) and the clamping bush (D). The cable glands and lock nuts are now available from ¾-in. B.S.P. to 1¼-in. conduit thread. Elkay Electrical Mfg. Co. Ltd., 42 Woburn Place, London, W.C.1.

EMD 3003 for further information

Tank Contents Gauge

A new pressure bulb-type hydrostatic tank contents gauge is capable of measuring the head of liquid in most types of non-pressurised tank, wherever situated and regardless of size and height. Its indicator can be placed up to 250 ft. from the tank to show, by a dial and pointer of from 4-12 in. diameter, either the depth of liquid or the tank contents. The gauge is said to be completely self-operative and offers continuous indication.

The gauge is supplied as two units, transmitter and indicator, together with suitable airline and connectors. The tank liquid fills the lower chamber of the transmitter unit to apply a pressure against the lower surface area of a synthetic-rubber pressure bulb. This pressure, the hydrostatic head of liquid in the tank, is transmitted through a small-bore copper or nylon air line to the indicator. It is necessary to know the density of the fluid in order to calibrate the indicator in depth units and also the tank size and shape if readings are required in volume or mass units. It is said that, by reducing stiffness in the pressure bulb as much as possible, errors due to change in atmospheric pressure or in the temperature or the air in the sealed system have been reduced to negligible proportions.

The gauge is suitable for all liquids compatible with the materials of the bulb and its housing, and six types of installation are available. The maximum recommended working temperature of the transmitter is 65 deg. C. Additional accessories are available to provide high-or low-level alarm indications, or automatic control of a pump to maintain liquid level in the tank. Firth Cleveland Instruments Ltd., Stornoway House, Cleveland Row, London, S.W.1.

EMD 3004 for further information

EMD 2911 for further information

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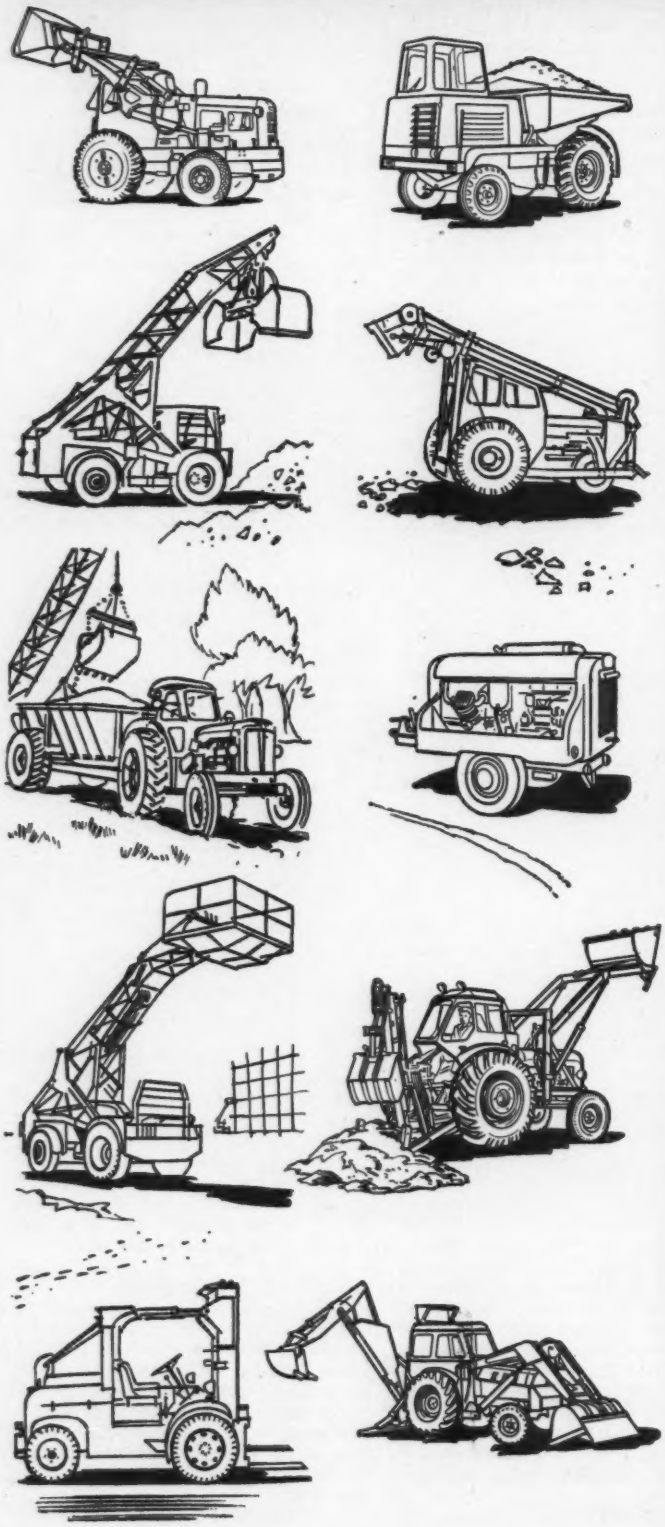

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Men who have kept to the tightest schedules in the toughest conditions; men who have manned machines working round the clock, seven days a week; these are the men who know from experience that for proved reliability Fordson Power is unequalled. Add to reliability all the other Fordson advantages of high output, low costs, unrivalled service and spare parts organisation, and almost unlimited choice of build-ups in the 30-40 and 40-50 b.h.p. classes. That's why more Fordson power units than any other are used in industrial equipment. Write for detailed specifications.

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Bright Platinum Plating

Bright, heavy and coherent deposits may be obtained, it is said, with a stable platinum plating solution recently introduced with the name of DNS. This bath is based on the complex sulphato-dinitrito-platinous acid, $H_2Pt(No_2)_2SO_4$. The bath is acidic and may therefore be used successfully on electrical components and printed circuits. Platinum from DNS solution can be deposited directly on to copper, brass, silver, nickel, aluminium and titanium. For deposition on tin, zinc, cadmium or steel an undercoat of silver or nickel is necessary.

Deposits from the new bath are said to be exceptionally bright and to need no polishing. Electrographic tests have shown no evidence of porosity in deposits up to 0.001 in. thickness on polished copper. Above this thickness some slight evidence of cracking may be observed. Microhardness tests on deposits give values up to 400-450 V.P.N.

Character of the deposits is said to remain unchanged in the temperature range 30-70 deg. C., but the recommended operating temperature is 50 deg. C. Johnson, Matthey & Co. Ltd., 78 Hatton Garden, London, E.C.1.

EMD 3005 for further information

Stationary Field Clutches

A range of miniature instrument clutches, at present made in a standard range of five sizes, transmitting torques from 4·2 to 420 oz. in. at speeds up to 20,000 r.p.m., can be used as clutch/couplings, clutch/brakes and duplex clutches. In addition to these, there is a range of positive engagement clutches, having the same physical dimensions as the standard instrument clutch and capable of giving torques from 14 to 1,400 oz. in. at speeds up to 20,000 r.p.m. These can be used for indicator drives and for applications where a non-slip drive is of importance. Their rapid response characteristics make them suitable for high-frequency instrumentation. Crofts (Engineers) Ltd., Bradford.

EMD 3006 for further information

Lubrication Unit

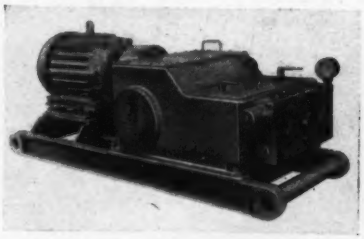
The service life of air-powered motors, cylinders, valves, etc., is said to be prolonged by the use of a new controlled airline lubrication unit, known as the Controlube. The unit consists of three parts. (1) A moisture separator for the efficient removal of condensed water and other impurities from the compressed air line; this is fitted with a replaceable filter and supplied with a drain cock. (2) A pressure-reducing valve complete with pressure gauge for use where it is necessary to reduce the main air line pressure for different services; it is fitted with a neoprene diaphragm. (3) A replaceable bowl lubricator to provide lubrication for all types of pneumatic tools by means of a regulated airborne oil fog. The oil flow is automatic and the rate of feed clearly visible through the sight glass. The oil feed is said to be easily and accurately adjusted by the screw on the top of the lubricator. Refilling can be done without closing the air flow.

For airline systems where a pressure reducing valve or other form of pressure control is already installed, the moisture separator and lubricator alone may be supplied. B.E.N. Patents, High Wycombe, Bucks.

EMD 3007 for further information

Hydraulic Pump

A new worm-driven hydraulic pump, known as the 853W/M, is announced. It has low plunger speeds and is of compact, all-steel construction, measuring 5 ft. long, 1 ft. 10 in. wide (without motor) and 1 ft. 8 in. high.



The pump unit is a 1½ × 2 in. horizontal triplex ram pump having a standard foot-mounting and is accommodated on a fabricated baseplate with skid ends and welded-in tubes for easy handling. It delivers 7·5 gal./min. at 1,400 p.s.i. Delivery is ¼ B.S.P. and suction 1 in. B.S.P. Joseph Evans & Sons (Wolverhampton) Ltd., Culwell Works, Wolverhampton, Staffs.

EMD 3008 for further information

Drip Regulator

The Condesco drip regulator, mainly used in conjunction with washing machines in the sterilising of bottles, is considered by the manufacturers to be suitable for many other applications where a dosage of acid or alkali in droplet form is required in accurately-measured quantities.

A main storage bottle of polythene feeds into a smaller container in the same material by means of a special connector which ensures that a constant head is obtained in this latter container. An automatic cut-off valve, operated by a hydraulic cylinder, is interposed between the constant rate bottle and the drip regulator valve, this cylinder being connected to the output of the final rinse pump of a bottle washer or similar supply, the minimum operating pressure being 10 p.s.i. As soon as the pressure is allowed to drop, the cut-off valve operates, thus eliminating waste and preventing any excess dosage when using corrosive materials. The regulators are supplied in 1-gal. and 5-gal. sizes. Lyne, Frank & Wagstaff Ltd., London Road, Enfield, Middx.

EMD 3009 for further information

Cable Cleat

Telcleats provide a means whereby most types of circular-section cable up to 2 in. diameter can be easily and securely affixed to a variety of surfaces. They are precision moulded in one piece and fixing is effected by means of a single hole, through which a suitable screw or bolt is passed. The material is black polythene and is said to be non-corrodible and non-corrosive and will not affect cable sheaths of plastics or metal. Good grip without slip is claimed.

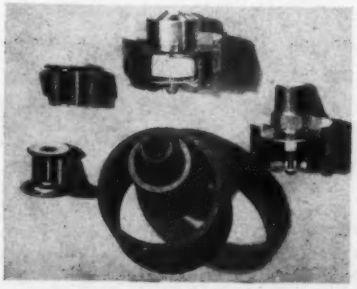
Telcleats are said to be suitable for mounting in cable trays, trunking or racks and to surfaces of brick, concrete, plaster, etc. They are said also to be suitable for domestic cold water installations using plastics tubing. Eleven sizes, ranging from 0·5 to 1 in., are available. Telegraph Construction & Maintenance Co. Ltd., Telcon Works, Greenwich, London, S.E.10.

EMD 3010 for further information

Filter Elements

A ribbon filter element is now being marketed for the efficient filtration of air, water, petrol, oil or other liquids where the particles to be removed are approximately 40 microns and above.

The element consists of a ribbon of resin-impregnated creped material helically-wound edgewise on a rotating mandrel and electrically polymerised and



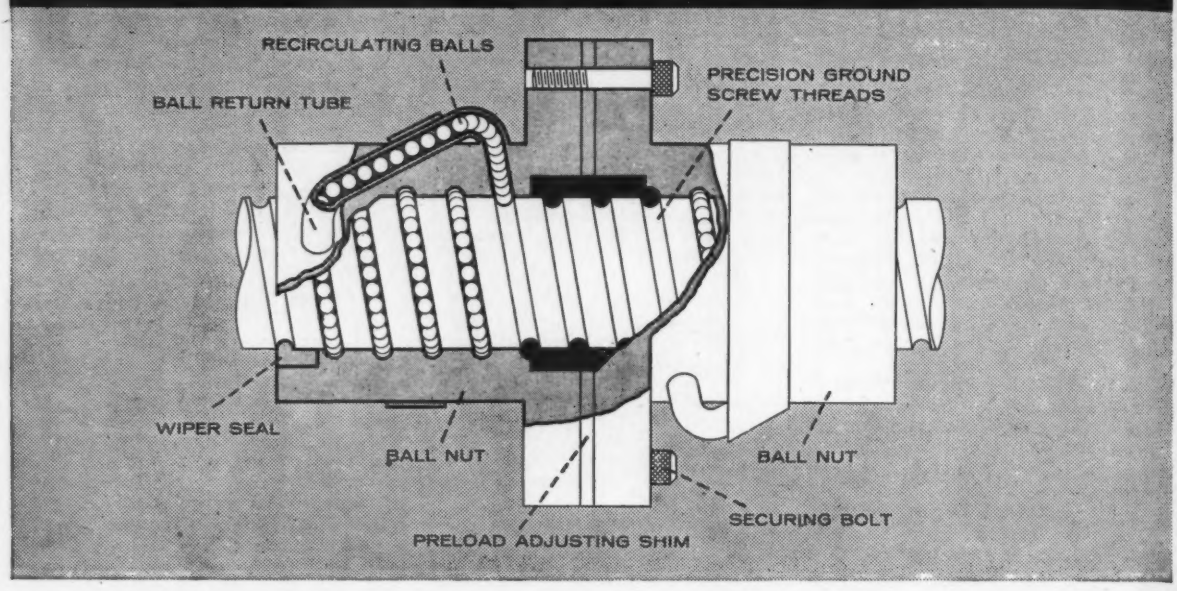
fused to form a hollow open-sided cylinder. The foreign matter is retained on the ribbon edges, inside or outside the cylinder, according to the direction of flow.

The elements will be available in sizes varying in outside diameter between ¼ and 6 in. and have a wall thickness from $\frac{1}{32}$ to ½ in. They are said to be easily cleaned for further use by washing in petrol or paraffin, or by blowing through with an air line. In some conditions a reversed flow of clean fluid or compressed air can be passed through the element, forcing the particles away from the ribbon edges.

They are also available in a range of air breather filters for crank-cases, gear and axle housings, vacuum and air brake systems, hydraulic reservoirs, pneumatic cylinders, etc. Tecalemit Ltd., Plymouth, Devon.

EMD 3011 for further information

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

** Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.*

For further information please write to J. B. Starky, Sales Manager (Beaver Products Division), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

High Vacuum Tap

An all-metal tap, having an open conductance of 0·3 litres/sec., a closed conductance of between 10^{-10} and 10^{-12} litres/sec. at a closing torque of approximately 25-30 lb. ft., suitable for operation at pressures of 10^{-9} mm. of Hg. without the use of vacuum grease, is now available. The maximum oven baking temperature for which the tap is suitable is 600 deg. C. Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

EMD 3012 for further information

Extensible Hydraulic Link

To enable large equipment having hydraulic lines to be articulated or flexed, without the disadvantages of looped hoses which might catch on obstructions, a form of hydraulic link known as Hi-Flex has been developed. It consists of a tubular member capable of being expanded and contracted axially, and employs a hydraulically-balanced mechanism which enables these movements to be carried out while fluid at high pressure is going through the appliance. The resistance to movement is claimed to be so low that little energy is absorbed when relative movement takes place between the end attachments.

In its present form the extensible hydraulic link is designed with plain tube ends, but could easily be produced with standard male or union ends. The standard model is adapted for ¼-in. feed lines, the extended length overall being 18¼ in., and fully retracted 15 in. This travel can, however, be extended for special services. The designed maximum working pressure is 3,000 p.s.i.

The unit is claimed to be leakproof and to be capable of functioning for extended periods before replacement of seals is required. The material in which the unit is made is mild steel plated and it is said that the moving parts are simple to remove and replace. Oil Feed Engineering Co. Ltd., Vincent House, Vincent Square, London, S.W.1.

EMD 3013 for further information

Hydraulic Accumulators

Three new series of hydraulic accumulators are announced. All three series are of screwed-end construction and incorporate safety interlocks to prevent the unit being dismantled whilst under internal pressure. Series II is for pressures up to 2,000 p.s.i. with capacities ranging from 8-20 gal./min. Series III is for pressures up to 5,000 p.s.i., with capacities ranging from 1-8 gal. Series IV is for pressures up to 5,000 p.s.i. with capacities ranging from 8-20 gal. Various port sizes and flanges are available.

All three accumulators embody the patented Liquid Seal piston assembly which is specially designed to overcome one of the main problems encountered with all gas-loaded piston separator-type accumulators, i.e., that of sealing the gas charge when the hydraulic system is shut down. The unique feature of this type of accumulator is said to be the probe which seals the oil outlet of the accumulator when it is discharged. Its effectiveness depends upon the fact that the oil trapped in the space between the piston and the end cover acts on the area less than the full piston area by the amount covered by the port sealing ring. This, in turn, means that the pressure of the trapped oil is greater than that of the gas charge in the ratio of full piston area stroke area acted on by the trapped oil. In this way, the problem is made much simpler and becomes simply one of retaining oil under a lower differential pressure. Should there be any leakage, due perhaps to deterioration of the piston seal after prolonged usage, then this would be of oil into the gas chamber rather than gas into the hydraulic system. Industrial Hydraulics Ltd., 101 London Road, Reading, Berks.

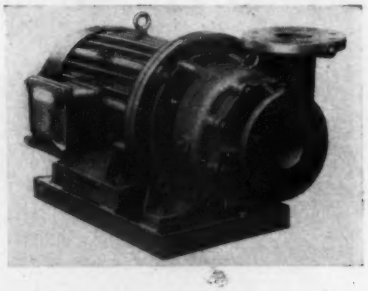
EMD 3014 for further information

Centrifugal Pumps

The Pegson-Sultan range of centrifugal pumps constitutes an attempt to rationalise the design and manufacture of forty-two pumps in such a way that a large number of the major parts are interchangeable within the range. It is stated that a normal number of separate parts would be about 1,250, whereas with the new range only 254 parts are required.

Basically, the Pegson-Sultan range of pumps is designed around six sets of constant hydraulic shapes. Each set of shapes is said to produce a uniform performance pattern so that a 12-in. pump, for example, is a pure geometric enlargement of any other model in the same hydraulic group. By keeping the suction eye constant for all pumps of the same suction branch diameter, it has been possible to reduce the number of parts and increase interchangeability.

The horsepower range, from ¼ to 75 h.p., is covered by five bearing housing groups and, within each group, all shafts, seals, bearings, caps, keys and H.D. bolt



locations are common. A choice of four interchangeable seals is available, mechanical self-lubricating shaft seals and a conventional stuffing box with gland packing. The seals are claimed to be suitable for a wide variety of liquids and all can be arranged for internal or external liquid circulation. The Sultan range is said to be suitable for general industrial, petroleum, marine, heating and irrigation duties. Pegson Ltd., Coalville, Leics.

EMD 3015 for further information

Valve Packings

Styles 1040 and 1041 mechanical packings are packaged units for use in valves and in control, compensating gear and servo mechanisms. They are said to seal positively and are pressure tight on rotary screw and axially moving spindles up to at least 500 p.s.i. They are claimed to virtually eliminate maintenance as compared with conventionally packed glands, this being significant when liquids and gases of a highly corrosive nature are handled.

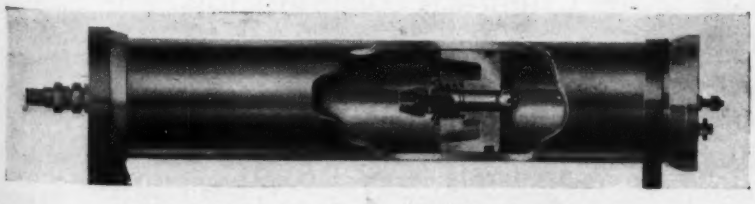
The two versions are designed respectively for press-in fit or for flange mounting. The temperature limit can be as high as 200 deg. C., depending on the material code recommended. Ease of installation, the freedom provided for the spindle to move without affecting the seal and the design opportunities for simplifying valves are among the advantages claimed. Crane Packing Ltd., Slough, Bucks.

EMD 3016 for further information

Self-cleaning Filter

For handling dust particles of virtually all sizes, a new air filter, known as the Tornado-Fischer automatic self-cleaning filter, is now available. Negligible maintenance is said to be necessary, it being necessary to lubricate only the motor and damper bearings occasionally; other moving parts are contained in dust-tight enclosures which enable them to function continuously without attention. Gas or air passing through the filter can be as high as 350 deg. C. in temperature. Keith Blackman Ltd., Mill Mead Road, London, N.17.

EMD 3017 for further information



A new hydraulic accumulator by Industrial Hydraulics Ltd.

new BONDERITE processes

The sodium-free 'Spra-Bonderite' 115 process is one of the new treatments referred to in this advertisement and is in full production use at the Cowley Works of Pressed Steel Company Limited.

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Pipeline Valve Actuator

A new form of actuator has recently been introduced which is suitable for hydraulic or pneumatic power operation of pipeline valves. It is designed for easy fitment to standard sluice, globe and butterfly valves and is said to make possible more simplified piping installations than have hitherto been used with conventional cylinders. Flexibility of design is claimed to be such that control may be manual, hydraulic, pneumatic or electrical in nature and either open-shut or positional control can be arranged. Hydraulics & Pneumatics Ltd., Wulfruna Works, Villiers Street, Wolverhampton.

EMD 3018 for further information

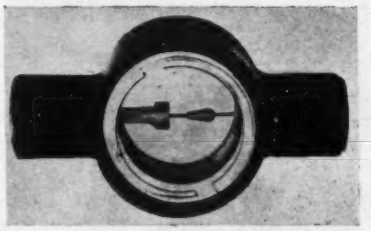
Transistorised Relay

A printed-circuit transistorised relay, having numerous advantages and measuring only 2 × 1¼ × 1¼ in., is now available. It requires a power supply of 12 volts d.c. at 30 mA. and operates with a current of 15 microamperes applied to the control circuit and is claimed to withstand an overload of one hundred times.

The contact and connectors are gold-plated throughout in order to minimise overall relay contact resistance. The printed circuit fits into a standard polarised 18-way (0·15 module) socket. B. & R. Relays Ltd., Temple Fields, Harlow, Essex.

EMD 3019 for further information

Low Flow Indicator



The Model 180 flow indicator has been primarily designed to give a positive flow indication only when the flow-rate exceeds ½ pint/min. It can be modified to indicate other rates of flow and can be supplied set to the desired flow rate. Liquid Systems Ltd., Holmethorpe Avenue, Redhill, Surrey.

EMD 3020 for further information

. . . at the Mechanical Handling Exhibition

Overhead Crane System

A new type of overhead crane system is being shown. It consists of two or more parallel MonoRail runways, usually attached to convenient roof members, covering the length of the area it is desired to service, and spanned by a bridge attached to trolleys running on the lower flanges of the runways. The bridge, which can be up to 200 ft. long, covers the width of the area, and carries the crane hoists of up to 5 tons capacity attached to trolleys running along the bridge rail. The cranes are fully motorised, and longitudinal movement of a load is achieved by moving the bridge along the runways, while for transverse travel the hoist is driven along the bridge rail.

These cranes have been specially designed to occupy minimum headroom so that they can be installed in existing buildings where headroom is limited without major structural change. British MonoRail Ltd., Wakefield Road, Brighouse, Yorks.

EMD 3021 for further information

Self-sealing Coupling

The Aeroquip 5600 Golden Flow is a quick-release self-sealing coupling with a special breakaway feature. By means of a simple push-pull action, the coupling can be connected or disconnected and, on disconnection, poppet valves contained within each coupling half-automatically seal off the hydraulic fluid. Use of the breakaway bracket enables one half of the coupling to be fixed so that an unexpected pull on the hose line immediately disconnects the coupling and seals off the fluid. The bracket can swivel through an angle of 30 deg. in all planes. Super Oil Seals & Gaskets Ltd., Factory Centre, Birmingham, 30.

EMD 3022 for further information

Traction Cell

The Kathanode N range of traction cell is specially designed for heavy-duty applications where the highest possible capacity is required in a limited space; for a given size cell, the range is said to offer a great increase in ampere-hour capacity over standard ranges, with a much improved capacity/weight ratio.

Cells of the Kathanode type are said to embody pasted positive and negative plates with improved grid alloys and active materials compounded to new formulæ; triple separation, consisting of ribbed Porvic, glass wool sheets and cedar veneers, protects and retains the active materials to a high degree.

Patented plate edge insulation is provided to prevent internal short circuits. D.P. Battery Co. Ltd., Bakewell, Derbys.

EMD 3023 for further information

F.H.P. Motor

A new type of fractional-horsepower d.c. motor, designated type BD.2506B, was on view. First developed some two years ago, this motor is now in full production as a standard machine. It has a stock rating of ¼ h.p. at 1,425 r.p.m., and instead of the previous laminated core and poles, now has solid iron core and poles and redesigned end shields and brushgear. A.E.I. Ltd., Rugby.

EMD 3024 for further information

Magnetic Clutches

Said to be of entirely new design, Autojust magnetic clutches and brakes have been specially developed for use in the gearboxes of machine tools. They are claimed to be particularly suitable where a number of clutches and brakes are to be incorporated, and where compactness is of value in keeping overall width to a minimum. They are intended to be oil sprayed in use, and never to need adjustment after installation.

Thirteen units are available, covering powers from fractional up to 45 h.p. Crofts (Engineers) Ltd. Thornbury, Bradford, 3, Yorks.

EMD 3025 for further information

Diesel Engine

The 60-h.p. 203(1) industrial diesel engine will be on view for the first time in the U.K. Suitable for many different types of industrial applications, this four-cylinder engine has a 3·6-in. bore, a 5-in stroke and 203 cu. in. (3·33 litre) capacity.

The engine is available with a hydraulic governor for variable speed applications, such as mobile cranes and fork-lift trucks, and is rated up to 60 b.h.p. at 2,400 r.p.m. When fitted with a mechanical governor for continuous use, the motor develops up to 47 b.h.p. at 2,000 r.p.m. Features include adequate provision for power take-offs and chromium-plated steel thin wall liners. Perkins Engines Ltd., Peterborough.

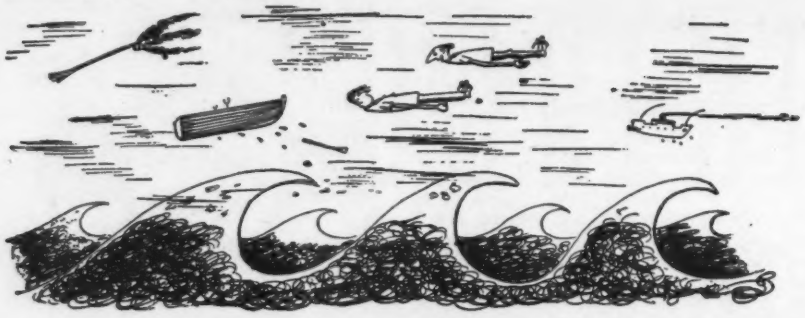
EMD 3026 for further information

Nylon Belting

HDNF (Heavy Duty Nylon Fill) conveyor belting comprises a special weave that combines the proper balance of strong crosswise nylon fill yarns with rugged cotton warp yarns running lengthwise. This is said to result in exceptional impact resistance and to maintain excellent troughability with a capacity for big loads. A quality known as Stacker is recommended for the severest conditions handling abrasive materials such as ore, coke, rock, glass cullet or granite, and, it is said, it may be used up to 200 deg C. Style B is recommended for coal, sand, gravel and general service. The Goodyear Tyre & Rubber Co. (Gt. Britain) Ltd., 36 Buckingham Gate, London, S.W.1.

EMD 3027 for further information

EMD 2914 for further information



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This Booth was started up on production on 1st March, 1959, and has operated two nine-hour shifts on continuous painting of agricultural machinery. When last examined, there was an average depth of silt of 6 inches over the entire water tank bottom, an area of 290 sq. feet. A further 4 inches, making 10 inches in all, can be accommodated before cleaning is essential. After 1 year's operation, the fan and ducting were barely discoloured, the only maintenance cost being cleaning the floor inside the booth, routine greasing of bearings and similar preventive maintenance.

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News of Industry

More than 2,000 delegates from various parts of the U.S.A. are expected to attend this year's **Design Engineering Conference** in New York, organised by the American Society of Mechanical Engineers. Among the topics set for discussion are (1) influence of nuclear and space technology on commercial products; (2) increasing the reliability of tools and products; (3) high-strength, high-temperature materials; and (4) the application of computers. The conference will take place from May 23-26, running concurrently with an exhibition.

Cover-to-cover translations of the Soviet welding journals, *Avtomaticheskaya Svarka* and *Svarochnoe Proizvodstvo*, are now being published each month by the **British Welding Research Association.**

A new strip mill, the first of its kind in Europe devoted to the rolling of aluminium alloys, has been installed by **Birmetals Ltd.** at a cost of £1 million. When the mill is in full operation, it will roll between 12,000 and 20,000 tons of aluminium sheet per year. The machine itself is a 50-in. reversing mill capable of rolling aluminium alloys in coil form at speeds up to 1,600 ft./min. The finished width of the coil obtained is 48 in. and the thicknesses which can be produced range from $\frac{3}{16}$ in. down to as little as 0·006 in. The 2½-in.-diameter work rolls are ground to such precision that the material produced has absolute uniformity across the width—a unique feature in the rolling of aluminium alloys.

A symposium on nuclear reactor containment buildings and pressure vessels is being held at the **Royal College of Science and Technology** in Glasgow from May 17-20.

Personnel from more than 200 companies have participated in the training courses in barrelling techniques since they were first started three years ago by **Roto-Finish Ltd.** Designed to give personnel an understanding of the variable factors of the process, they are intended primarily to ensure that best results are obtainable with barrelling plant and equipment. The courses are free and are held at Hemel Hempstead on the first Monday of each month (until the following Wednesday).

The largest-ever closed-circuit colour television picture, 18 × 24 ft., was produced by **Eidophor Inc.** recently for the American Academy of General Practice Conference in Philadelphia.

A new type of non-skid flooring composition based on epoxide resins has been developed by **Bakelite Ltd.** The material is said to be suitable for use in locations such as stairs, steps, ramps, loading bays and even on road surfaces.

A.E.I. Ltd. is to supply electric traction equipment worth nearly £3 million for use by South African Railways. The order is for traction motors, control gear and lighting and heating equipment for installation in 113 motor coaches.

Union Carbide International Ltd. is to set up a technical service laboratory for plastics in Geneva. It is understood it will be devoted primarily to rendering technical service to the European plastics industry, with the object of developing new uses and fabrication methods for polythene, styrenes, vinyls and phenolics.

A new way of using a symmetrical transistor—as a chopper—has been developed by **Smiths Aviation Division** principally for use with thermocouples. The company also visualises the use of its transistor chopper techniques in strain-gauge work.

In "New Ideas in Design" in the April issue of ENGINEERING MATERIALS AND DESIGN, the pitch and roll indicator referred to on page 239 was incorrectly ascribed to Woodhead Springs Ltd. This is in fact produced by **Toledo Woodhead Springs Ltd.**

The **Ergonomics Research Society** recently held its annual conference at Cambridge. Speakers during the various sessions were drawn from the U.S.A., Sweden, Germany and the Netherlands, in addition to a large number of representatives of British universities and industrial and research organisations.

A total of thirty separate courses covering the principal branches of industry are being held by the **Institute of Welding's** school of welding technology during the period April-October this year. Two full-time day courses are now being offered each month. These are held in London, but evening courses are held in a number of main industrial centres.

The **United Steel Cos.** are to award ten annual scholarships, each worth £500 annually, for three or more years at a U.K. university.

Three British universities—University of Glasgow, University of North Staffordshire and the Imperial College of Science and Technology in London—are to share 1960 research grants of about £50,000 from the **U.S. Rubber Research Centre.** Research under the grants will include basic studies of the properties of polymers and colloids and the mechanism of creation and ageing of new fibres, plastics and rubbers.

The U.S. Rubber Research Centre is supported by the U.S. Rubber Co., whose British associates include Lastex Yarn and Lactron Thread Ltd. of London, North British Rubber Co. of Edinburgh, and Rubber Regenerating Co. Ltd. of Manchester.

Gresham Transformers Ltd. have just built what is believed to be the world's largest electromagnetic control system or transductor. The equipment, which weighs over 20 tons, will be used in conjunction with Westinghouse germanium rectifiers to control an output current of 12,000 amps. It is to be used for research work in Holland.

The **Head Wrightson Machine Co.** is manufacturing twenty-three copper conductor rolls, valued at £53,000 for the French firm Ets. Dujardin et Cie. These rolls, 24 in. diameter with a face width of 46 in., will form part of an electrolytic tinning line to be supplied to the Phenix Steelworks in Belgium and built under licence from the Aetna-Standard division of Blaw-Knox.

Since solid drawn copper tubing of 24 in. diameter could not be obtained, it was necessary to find a means by which the roll barrel could be formed by bending copper plate of 1-in. thickness. Head Wrightson developed a technique for the production of a homogeneous longitudinal weld along these shells. Having produced the shells, the rolls were built up by inserting phosphor-bronze shafts to which supporting webs had been welded.

Machining a copper conductor roll for an electrolytic tinning line in the works of Head Wrightson Machine Co. Ltd. (See story this page.)

It has been announced that Mr. A. Geoffrey Banks has been elected President of the **Engineering Centre**, Birmingham, in succession to Mr. Victor Brenner who has held the office for the past four years. Mr. Banks is a Director of Johnsons Iron & Steel Co. Ltd. and Johnsons Rolls Ltd, both of West Bromwich. He has been a member of the committee of the Engineering Centre for six years, the last four as Hon. Treasurer.

Sciaky Electric Welding Machines Ltd. in association with Pye Industries Ltd. announce the formation of an Australian company called Sciaky Australia (Pty.) Ltd. to manufacture, install and service resistance welding equipment for the Australasian Continent.

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★ The inside diameter is supplied rough machined.
Standard 13″ lengths

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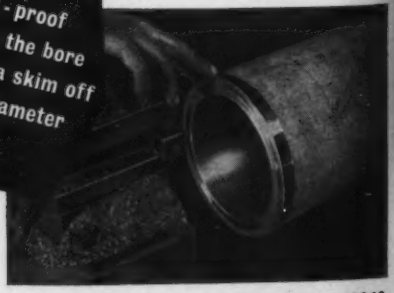
machined in the bore
- needs only a skim off
the outside diameter
- easy on tools



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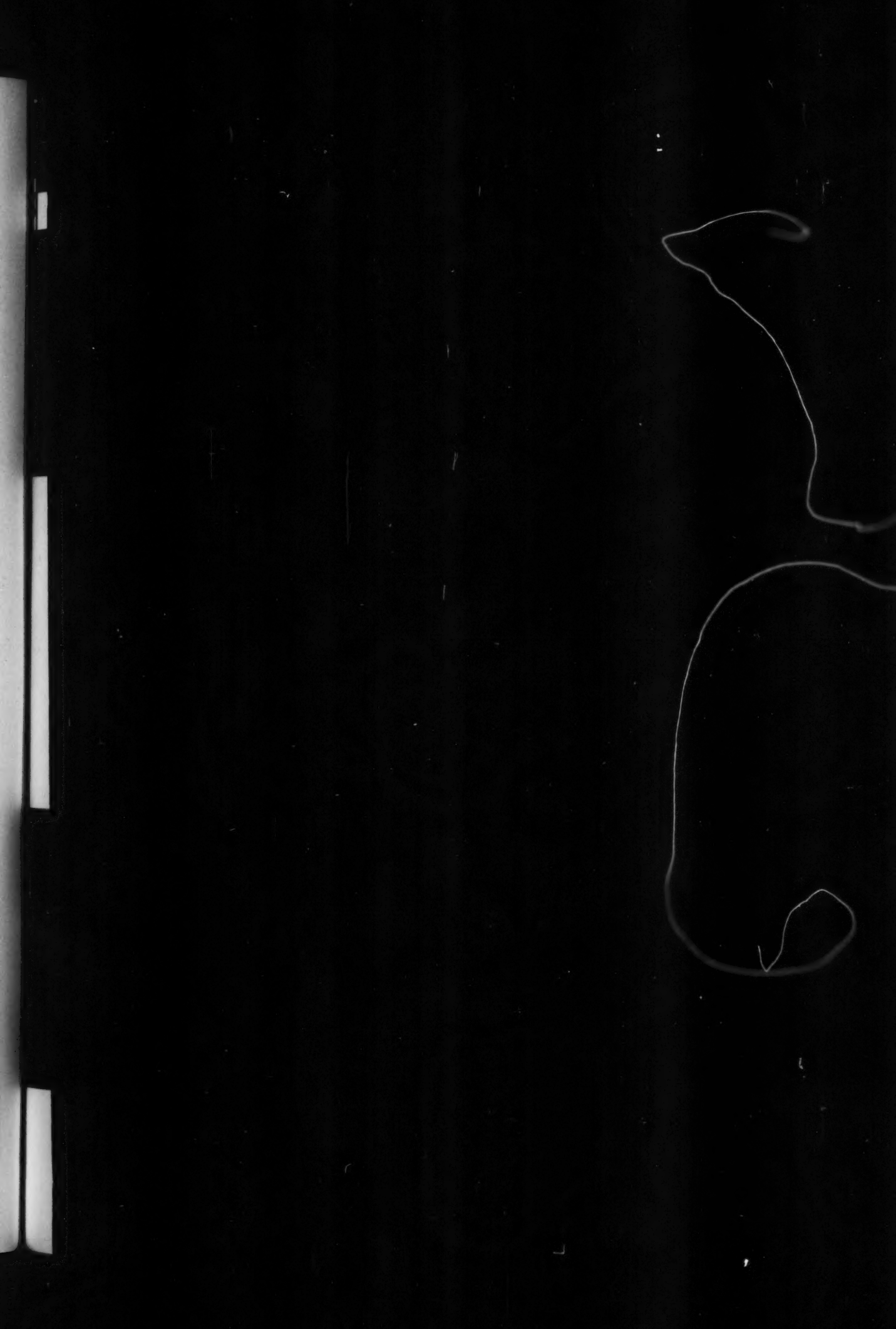
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